

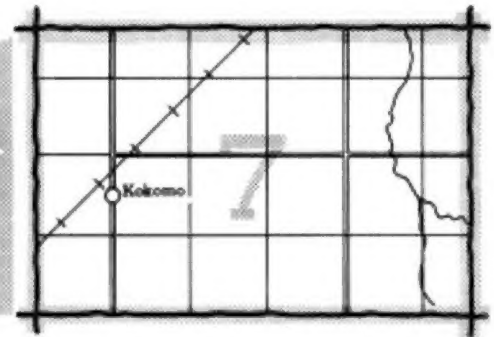
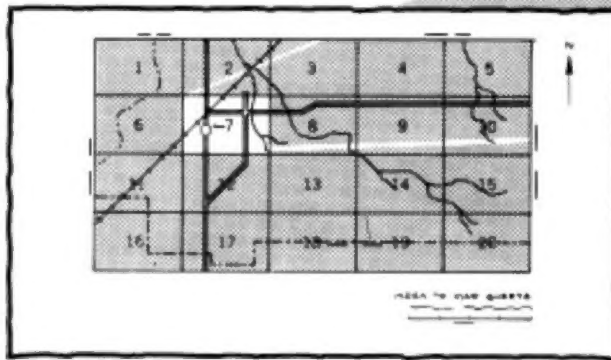
Soil survey of
Doniphan County
Kansas



United States Department of Agriculture
Soil Conservation Service
in cooperation with
Kansas Agricultural Experiment Station

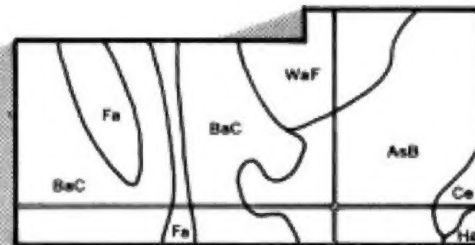
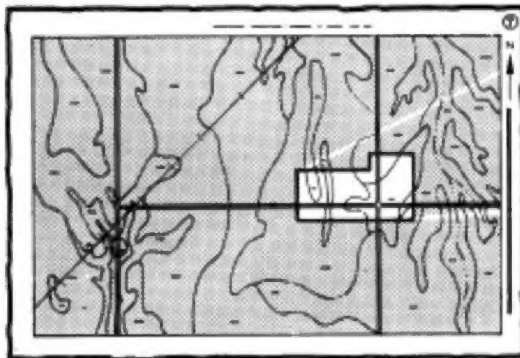
HOW TO USE

1. Locate your area of interest on the "Index to Map Sheets"

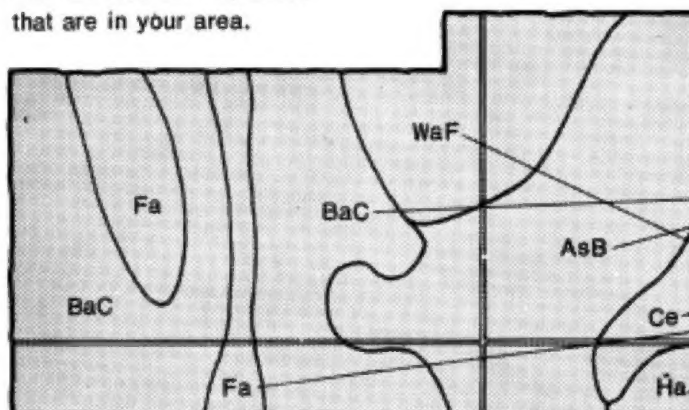


2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.



4. List the map unit symbols that are in your area.



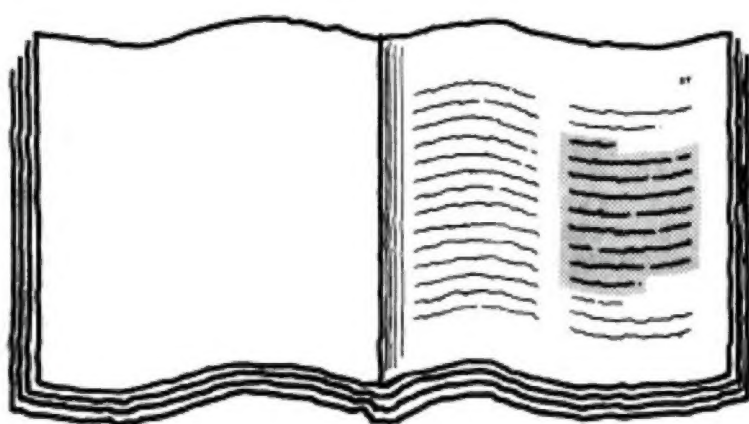
Symbols

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THIS SOIL SURVEY

5.

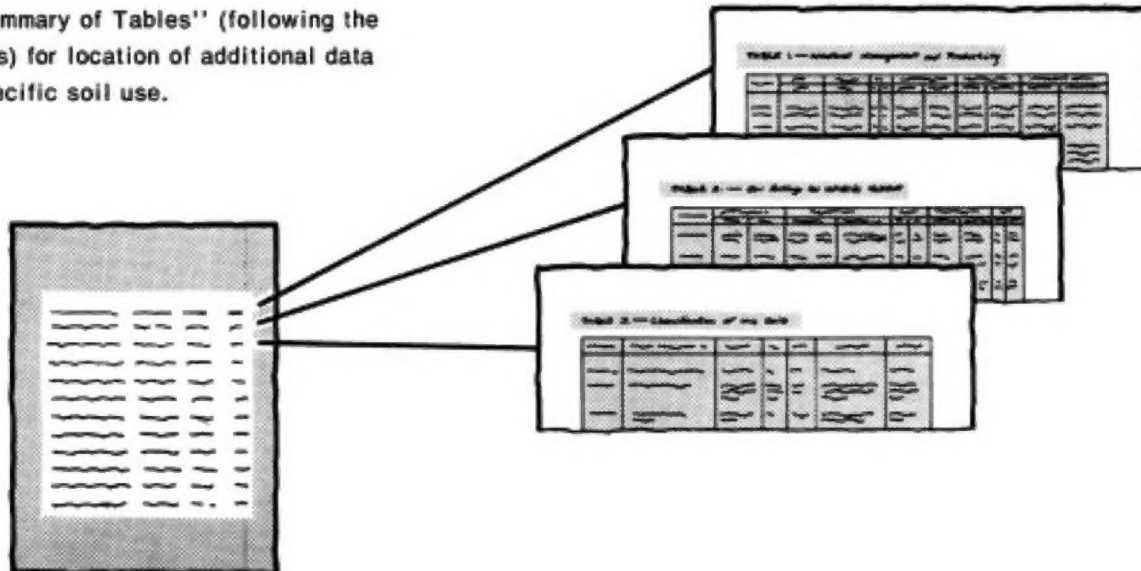
Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



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6.

See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7.

Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Doniphan County Conservation District. Financial assistance was provided by the Doniphan County Commissioners. Major fieldwork was performed in the period 1973-1977. Soil names and descriptions were approved in 1977. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1977.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Cover: An area of Monona and Morrill soils. Morrill soils are on the lower slopes.

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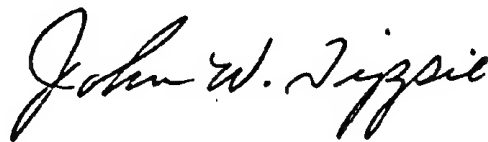
Foreword

This soil survey contains information that can be used in land-planning programs in Doniphan County, Kansas. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations inherent in the soil or hazards that adversely affect the soil, improvements needed to overcome the limitations or reduce the hazards, and the impact of selected land uses on the environment.

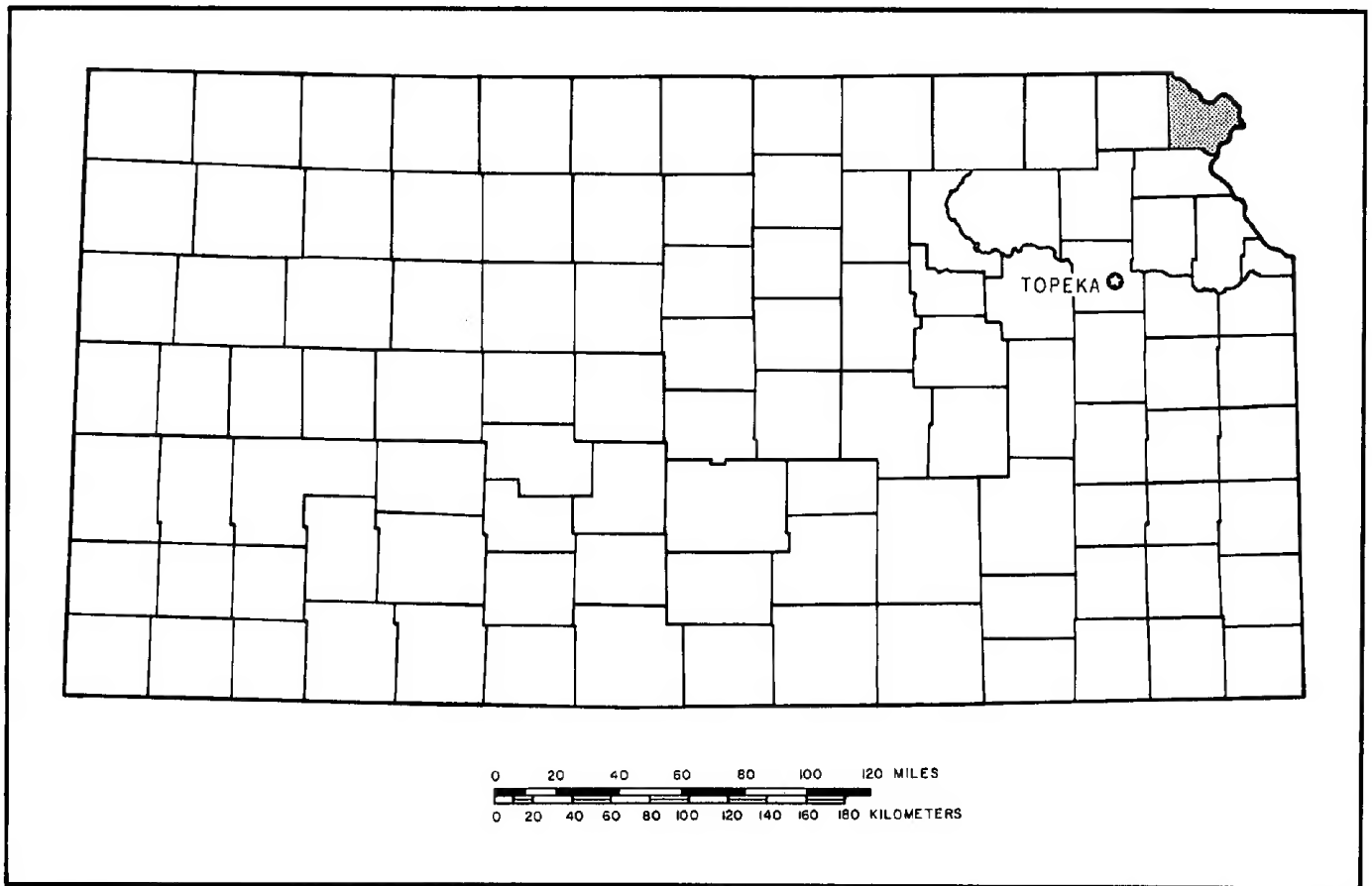
This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

A handwritten signature in black ink, reading "John W. Tippie". The signature is fluid and cursive, with the first letters of each word being capitalized and prominent.

John W. Tippie
State Conservationist
Soil Conservation Service



Location of Doniphan County in Kansas.

SOIL SURVEY OF DONIPHAN COUNTY, KANSAS

By Kenneth H. Saltee, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in
cooperation with Kansas Agricultural Experiment Station

General nature of the county

DONIPHAN COUNTY is in the northeastern corner of Kansas. It is bordered on the east and on the north by the Missouri River, which separates it from Missouri. It has a total land area of 248,576 acres, or about 388 square miles. In 1977, the population of the county was 10,016 and that of Troy, the county seat, was 1,238. The county was organized in 1855.

Lookout Mountain, the highest point in the county, has an elevation of 1,195 feet. The lowest elevation is 780 feet, at a point along the Missouri River near Doniphan. Local relief is as much as 300 feet in the northern part of the county.

The northern and eastern parts of the county are in the Iowa and Missouri Deep Loess Hills land resource area, and the rest is in the Nebraska and Kansas Loess-Drift Hills land resource area. The Iowa and Missouri Deep Loess Hills have a succession of very steep hills and deeply entrenched valleys that join the valley of the Missouri River. The landscape is rolling and hilly in the areas farther from the river valley. The soils in the Missouri Deep Loess Hills are deep and strongly sloping to very steep. They formed in silty loess. The soils in the Nebraska and Kansas Loess-Drift Hills generally are deep, gently sloping to steep, and silty and loamy.

Farming is the most important enterprise in the county. Corn, soybeans, wheat, and grain sorghum are the main crops. Apples are an important crop in the eastern part of the county. Cattle and hogs are the main kinds of livestock.

Climate

By L. Dean Bark, climatologist, Kansas Agricultural Experiment Station, Manhattan, Kansas.

Doniphan County has a typical continental climate, as can be expected in an area in the interior of a large land mass in the middle latitudes. The climate is characterized by wide daily and annual variations in temperature.

Winters are cold because of frequent outbreaks of polar air. They last from December to February. Warm summer temperatures last for about 6 months every year. They provide a long growing season for crops. Spring and fall are generally short.

The county is in the path of a fairly dependable current of moisture-laden air from the Gulf of Mexico. Precipitation is heaviest late in spring and early in summer. Much of it falls during late-evening or nighttime thunderstorms. Although the total precipitation is generally adequate for any crop, its distribution causes problems in some years. Prolonged dry periods of several weeks can occur during the growing season. A surplus of precipitation often results in muddy fields, which delay planting and harvesting.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Troy in the period 1949 to 1970. Temperature records were not kept in Doniphan County before 1949. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 29.7 degrees F, and the average daily minimum temperature is 19.9 degrees. The lowest temperature, which occurred at Troy on January 12, 1974, is minus 18 degrees. In summer the average temperature is 75.5 degrees, and the average daily maximum temperature is 86.4 degrees. The highest recorded temperature, which occurred at Troy on July 13, 1954, is 106 degrees. Temperature extremes of minus 30 and plus 112 degrees have been recorded in nearby Brown County.

The average annual precipitation is 35.03 inches. Of this total, 75 percent usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 20.23 inches. The heaviest 1-day rainfall during the period of record was 6.80 inches at Troy on May 3, 1958.

Tornadoes and severe thunderstorms occur occasionally, but they last for only a short period and are local in extent. The risk of crop damage is small. Hailstorms occur during the warmer part of the year, but they are infrequent and local in extent. The hail can damage crops, but the risk is less serious in this county than in western Kansas.

Average seasonal snowfall is 20.1 inches. The greatest snow depth at any one time during the period of record was 19 inches. On an average of 23 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The sun shines 70 percent of the time possible in summer and 55 percent in winter. The prevailing wind is from the south. Average windspeed is highest, 12 miles per hour, in March and April.

Natural resources

Soil is the most important natural resource in the county. It provides a growing medium for cultivated crops and for the pasture and range plants grazed by livestock.

Other natural resources in Doniphan County are limestone and sand and gravel. A large amount of limestone is quarried and used as riprap along the Missouri River or as road surfacing material. A small amount of sand and gravel is deposited in areas of glacial till.

How this survey was made

Soil scientists made this survey to learn what soils are in the survey area, where they are, and how they can be used. They observed the steepness, length, and shape of slopes; the size of streams and the general pattern of drainage; the kinds of native plants or crops; and the kinds of rock. They dug many holes to study soil profiles. A profile is the sequence of natural layers, or horizons, in a soil. It extends from the surface down into the parent material, which has been changed very little by leaching or by plant roots.

The soil scientists recorded the characteristics of the profiles they studied and compared those profiles with others in nearby counties and in more distant places. They classified and named the soils according to nationwide uniform procedures. They drew the boundaries of the soils on aerial photographs. These photographs show trees, buildings, fields, roads, and other details that help in drawing boundaries accurately. The soil maps at the back of this publication were prepared from aerial photographs.

The areas shown on a soil map are called map units. Most map units are made up of one kind of soil. Some are made up of two or more kinds. The map units in this survey area are described under "General soil map for broad land use planning" and "Soil maps for detailed planning."

While a soil survey is in progress, samples of some soils are taken for laboratory measurements and for en-

gineering tests. All soils are field tested to determine their characteristics. Interpretations of those characteristics may be modified during the survey. Data are assembled from other sources, such as test results, records, field experience, and state and local specialists. For example, data on crop yields under defined management are assembled from farm records and from field or plot experiments on the same kinds of soil.

But only part of a soil survey is done when the soils have been named, described, interpreted, and delineated on aerial photographs and when the laboratory data and other data have been assembled. The mass of detailed information then needs to be organized so that it can be used by farmers, rangeland and woodland managers, engineers, planners, developers and builders, home buyers, and others.

General soil map for broad land use planning

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each association on the general soil map is a unique natural landscape. Typically, an association consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one association can occur in another but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The names and descriptions of the soils identified on the general soil map for this county do not fully agree with those of the soils identified on the maps for adjacent counties. Differences result from a better knowledge of the soils, modifications in series concepts, a higher or lower intensity of mapping, and variations in the extent of the soils.

Descriptions of associations

1. Monona association

Deep, gently sloping to moderately steep, well drained soils that have a silt loam subsoil; on uplands

This association consists of dominantly gently sloping to moderately steep soils on convex ridgetops and side slopes. The soils are steeper in the more deeply entrenched areas along the Missouri and Wolf Rivers.

This association makes up about 46 percent of the county. It is about 80 percent Monona soils and 20 percent minor soils.

The Monona soils formed in loess on ridgetops and side slopes. Typically, the surface soil is very dark grayish brown silt loam about 11 inches thick. The subsoil is brown silt loam about 14 inches thick. The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam.

The minor soils in this association are Hamburg, Kennebec, Knox, and Morrill soils. The calcareous Hamburg soils are in the steeper areas. The Kennebec soils are on flood plains along drainageways. The Knox soils are in positions on the landscape similar to those of Monona soils. They have a thinner surface soil. The reddish Morrill soils are on foot slopes.

This association is used mainly for cultivated crops. It is the main corn growing area in the county. Soybeans and grain sorghum are also grown. Some small areas are used for hay, pasture, or orchards. Water erosion is a hazard. Controlling erosion and maintaining tilth and fertility are concerns in managing this association.

This association has good to fair potential for cultivated crops. It has good potential for pasture and for openland and woodland wildlife habitat. It has fair to poor potential for building site development and sanitary facilities.

2. Hamburg-Monona association

Deep, moderately steep and steep, somewhat excessively drained and well drained soils that have a silt loam subsoil; on uplands

This association consists of dominantly moderately steep and steep soils on dissected bluffs adjacent to the valley of the Missouri River (fig. 1). Streams dissecting the area are deeply entrenched. A 200- to 300-foot change in elevation within a short distance is common.

This association makes up about 6 percent of the county. It is about 60 percent Hamburg soils, 30 percent Monona soils; and 10 percent minor soils.

The somewhat excessively drained Hamburg soils formed in loess on side slopes and ridgetops. Typically, the surface layer is brown, calcareous silt loam about 4



Figure 1.—Typical area of the Hamburg-Monona association.

inches thick. The next 7 inches is brown, strongly calcareous silt loam. The substratum to a depth of about 60 inches is dark yellowish brown and brown, strongly calcareous silt loam.

The well drained Monona soils formed in loess on ridgetops. Typically, the surface soil is very dark grayish brown silt loam about 11 inches thick. The subsoil is brown silt loam about 14 inches thick. The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam.

The minor soils in this association are Kennebec, Sogn, and Vinland soils. The Kennebec soils are on flood plains along drainageways. The shallow Sogn and Vinland soils are in the steeper areas. Limestone commonly crops out in the steep areas on the bluffs along the Missouri River.

Most of this association formerly was farmed or used for orchards. Most areas are now used for pasture, but some small areas support trees. The major management concerns are the hazard of erosion and the growth and vigor of the grasses. An adequate plant cover and ground mulch help to prevent excessive soil losses and reduce the runoff rate.

This association has poor potential for cultivated crops and good to fair potential for pasture. It has fair potential for woodland wildlife habitat and poor potential for building site development and sanitary facilities.

3. Knox-Monona association

Deep, moderately sloping to moderately steep, well drained soils that have a silt loam and silty clay loam subsoil; on uplands

This association consists of dominantly moderately sloping to moderately steep soils on convex ridgetops and side slopes. In areas along deeply entrenched streams, the soils are steeper.

This association makes up about 8 percent of the county. It is about 80 percent Knox soils, 10 percent Monona soils, and 10 percent minor soils.

The Knox soils formed in loess on side slopes and ridgetops. Typically, the surface layer is dark brown silt loam about 8 inches thick. The upper part of the subsoil is dark yellowish brown silty clay loam. The lower part to a depth of more than 60 inches is brown, mottled silt loam.

The Monona soils formed in loess on ridgetops and side slopes. Generally, they are further from rivers than the Knox soils. Typically, the surface soil is very dark grayish brown silt loam about 11 inches thick. The subsoil is brown silt loam about 14 inches thick. The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam.

The minor soils in this association are Hamburg, Kennebec, and Sogn soils. The calcareous Hamburg soils are in the steeper areas adjacent to the valley of the Missouri River. The Kennebec soils are on flood plains along drainageways. The Sogn soils are on side slopes. They are shallow or very shallow over limestone bedrock. Limestone commonly crops out along the entrenched drainageways.

This association is used mainly for cultivated crops. Some areas are used for hay, pasture, orchards, or trees. Corn, grain sorghum, soybeans, and small grain are the main cultivated crops. Water erosion is a hazard. Controlling erosion and maintaining tilth and fertility are concerns in managing the major soils.

This association has fair to poor potential for cultivated crops and woodland. It has good potential for pasture and for openland and woodland wildlife habitat and poor potential for building site development and sanitary facilities.

4. Marshall-Morrill-Grundy association

Deep, nearly level to strongly sloping, well drained and somewhat poorly drained soils that have a clay loam to silty clay subsoil; on uplands

This association is on ridgetops and side slopes that are dissected by drainageways and creeks. It makes up about 11 percent of the county. It is about 55 percent Marshall soils, 20 percent Morrill soils, 8 percent Grundy soils, and 17 percent minor soils (fig. 2).

The well drained Marshall soils formed in loess on side slopes and ridgetops. Typically, the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsoil is silty clay loam about 47 inches thick. The upper part is very dark grayish brown, the middle part is dark brown and brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam.

The well drained Morrill soils formed in glacial till on the lower side slopes along drainageways. Typically, the surface layer is very dark grayish brown loam about 5 inches thick. The subsoil to a depth of about 60 inches is clay loam. The upper part is dark brown, the middle part is reddish brown, and the lower part is reddish brown and brown.

The somewhat poorly drained Grundy soils formed in loess on broad ridgetops and side slopes. Typically, the surface soil is black silty clay loam about 13 inches thick. The subsoil is about 34 inches thick. The upper part is very dark brown silty clay loam. The middle part is very dark grayish brown and dark grayish brown, mottled silty clay. The lower part is dark gray and grayish brown, mottled silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled silty clay loam.

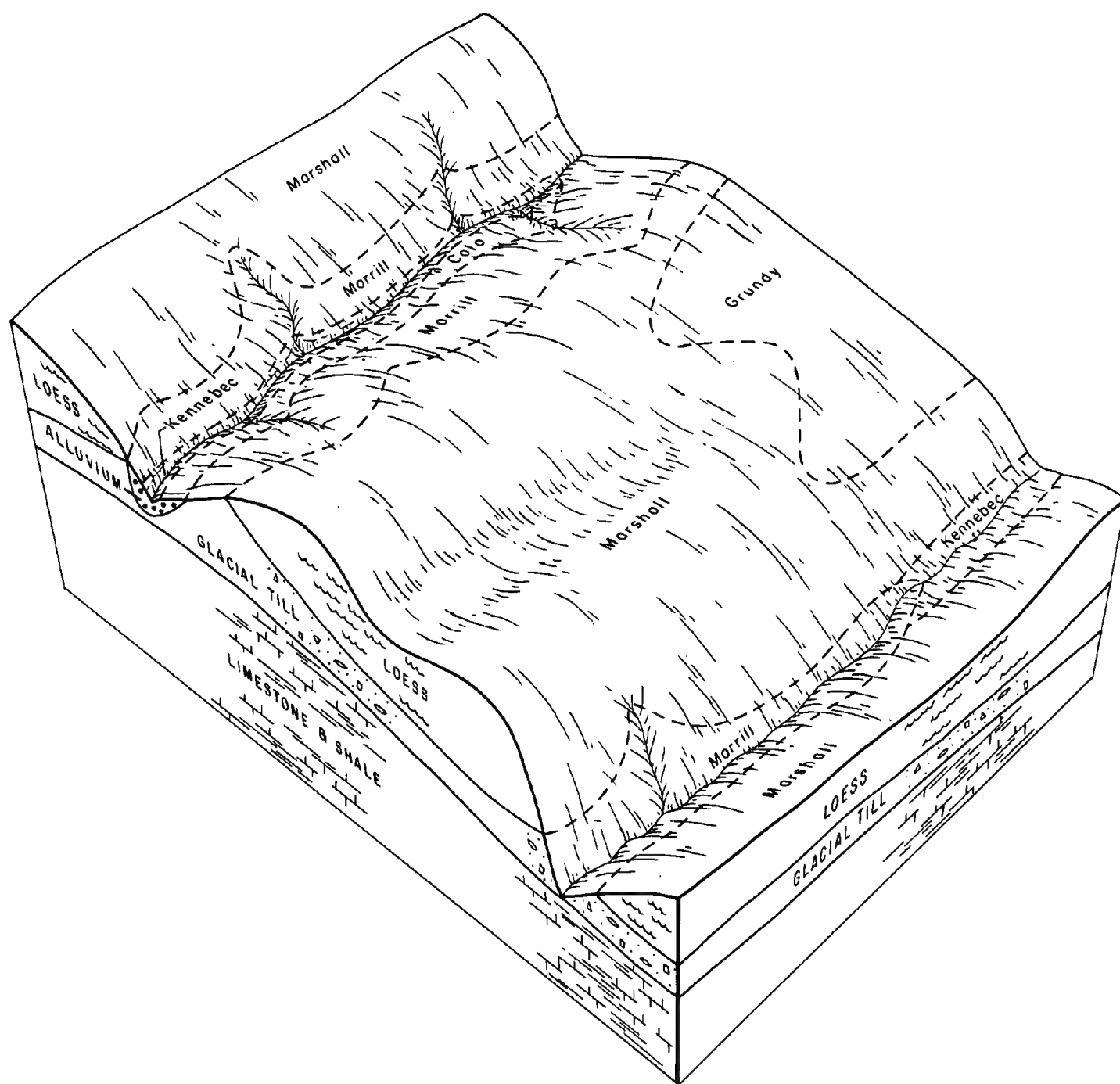


Figure 2.—Typical pattern of soils in the Marshall-Morrill-Grundy association.

The minor soils in this association are Colo, Kennebec, Martin, and Vinland soils. The Colo and Kennebec soils are on flood plains along drainageways. The clayey Martin soils are on foot slopes. The shallow Vinland soils are in the steeper areas.

This association is used mainly for cultivated crops. Some small areas are used for hay or pasture. Corn, grain sorghum, soybeans, and small grain are the main cultivated crops. Water erosion is a hazard in the gently sloping to strongly sloping areas. Controlling erosion and

maintaining tilth and fertility are concerns in managing the major soils.

This association has good to fair potential for cultivated crops and for openland and woodland wildlife habitat. It has good potential for pasture and fair to poor potential for building site development and sanitary facilities.

5. Marshall-Monona-Morrill association

Deep, moderately sloping to moderately steep, well drained soils that have a silty clay loam, silt loam, and clay loam subsoil; on uplands.

This association is on convex ridgetops and side slopes on uplands that are dissected by drainageways and creeks. It makes up about 5 percent of the county. It is about 30 percent Marshall soils, 30 percent Monona soils, 20 percent Morrill soils, and 20 percent minor soils (fig. 3).

The Marshall soils formed in loess on ridgetops and side slopes. Typically, the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsoil is silty clay loam about 47 inches thick. The upper part is very dark grayish brown, the middle part is dark brown and brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam.

The Monona soils formed in loess on side slopes. Typically, the surface soil is very dark grayish brown silt loam about 11 inches thick. The subsoil is brown silt loam about 14 inches thick. The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam.

The Morrill soils formed in glacial till on the lower side slopes along drainageways. Typically, the surface layer is very dark grayish brown loam about 5 inches thick. The subsoil to a depth of about 60 inches is clay loam. The upper part is dark brown, the middle part is reddish brown, and the lower part is reddish brown and brown.

The minor soils in this association are Kennebec, Martin, Sogn, and Vinland soils. The Kennebec soils are on flood plains along drainageways. The clayey Martin soils are on foot slopes. The shallow or very shallow Sogn and Vinland soils are in the steeper areas.

This association is used mainly for cultivated crops. Some small areas are used for hay and pasture. Corn, soybeans, grain sorghum, and small grain are the main cultivated crops. Water erosion is a hazard. Controlling erosion and maintaining tilth and fertility are concerns in managing the major soils.

This association has good to fair potential for cultivated crops and good potential for pasture and for openland wildlife habitat. It has fair potential for building site development and sanitary facilities.

6. Knox-Marshall-Vinland association

Deep or shallow, moderately sloping to moderately steep, well drained and somewhat excessively drained soils that have a silty clay loam and silt loam subsoil; on uplands

This association is on ridgetops and side slopes that are deeply dissected by drainageways and creeks. It makes up about 9 percent of the county. It is about 30 percent Knox soils, 25 percent Marshall soils, 20 percent Vinland soils, and 25 percent minor soils (fig. 4).

The deep, well drained Knox soils formed in loess on ridgetops and side slopes. Typically, the surface layer is dark brown silt loam about 8 inches thick. The upper part of the subsoil is dark yellowish brown silty clay loam. The lower part to a depth of about 60 inches is brown, mottled silt loam.

The deep, well drained Marshall soils formed in loess on ridgetops. Typically, the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsoil is silty clay loam about 47 inches thick. The upper part is very dark grayish brown, the middle part is dark brown and brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam.

The shallow, somewhat excessively drained Vinland soils formed in material weathered from shale on side slopes. Typically, the surface layer is very dark brown silty clay loam about 8 inches thick. The subsoil is dark grayish brown silty clay loam about 4 inches thick. The substratum is olive brown silty clay loam. Weathered silty shale is at a depth of about 17 inches.

Minor in this association are Kennebec, Morrill, Reading, and Sogn soils and Rock outcrop. The Kennebec soils are on flood plains along drainageways. The reddish Morrill soils are on side slopes above the Vinland soils. The moderately well drained Reading soils are on stream terraces. The Sogn soils are on side slopes near the Vinland soils. They are shallow or very shallow over limestone bedrock.

This association is used mainly for cultivated crops and for pasture. Some of the steeper areas and the areas along streams support trees. Corn, grain sorghum, soybeans, small grain, and brome grass are the main crops. Water erosion is a hazard. Controlling erosion and maintaining fertility and tilth are concerns in managing the major soils.

This association has fair to poor potential for cultivated crops and for woodland, building site development, and sanitary facilities. It has good potential for pasture and fair to good potential for woodland wildlife habitat.

7. Onawa-Haynie-Albaton association

Deep, nearly level, moderately well drained to poorly drained soils that have a silt loam to silty clay subsoil; on flood plains

This association is on flood plains in the valley of the Missouri River. It makes up about 10 percent of the

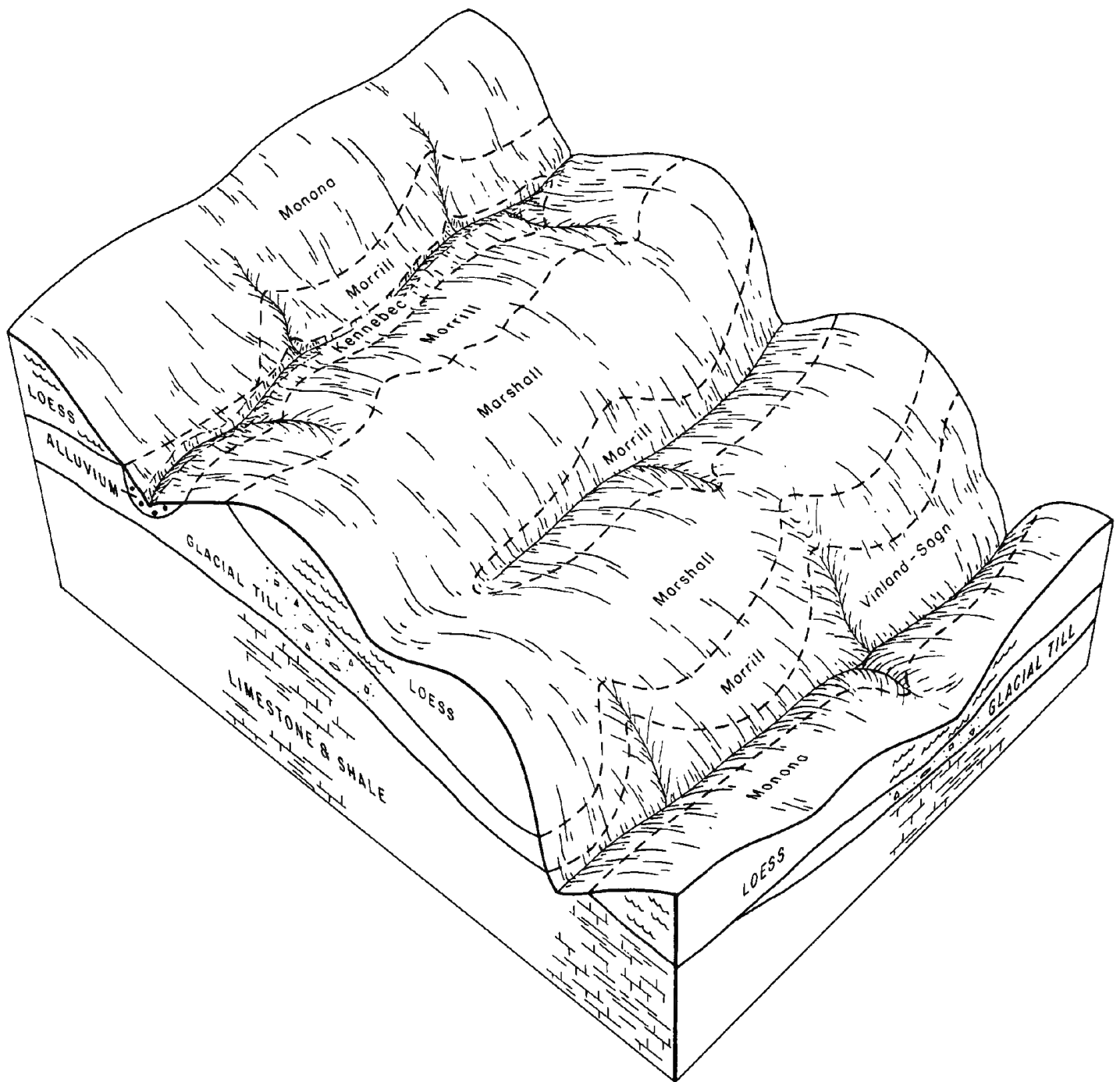


Figure 3.—Typical pattern of soils in the Marshall-Monona-Morrill association.

county. It is about 50 percent Onawa soils, 30 percent Haynie soils, 10 percent Albaton soils, and 10 percent minor soils.

The somewhat poorly drained Onawa soils formed in clayey and loamy alluvium. Typically, the surface layer is

very dark grayish brown silty clay loam about 8 inches thick. The upper part of the substratum is dark grayish brown, mottled silty clay, and the lower part to a depth of about 60 inches is stratified, dark grayish brown, mottled very fine sandy loam and silt loam.

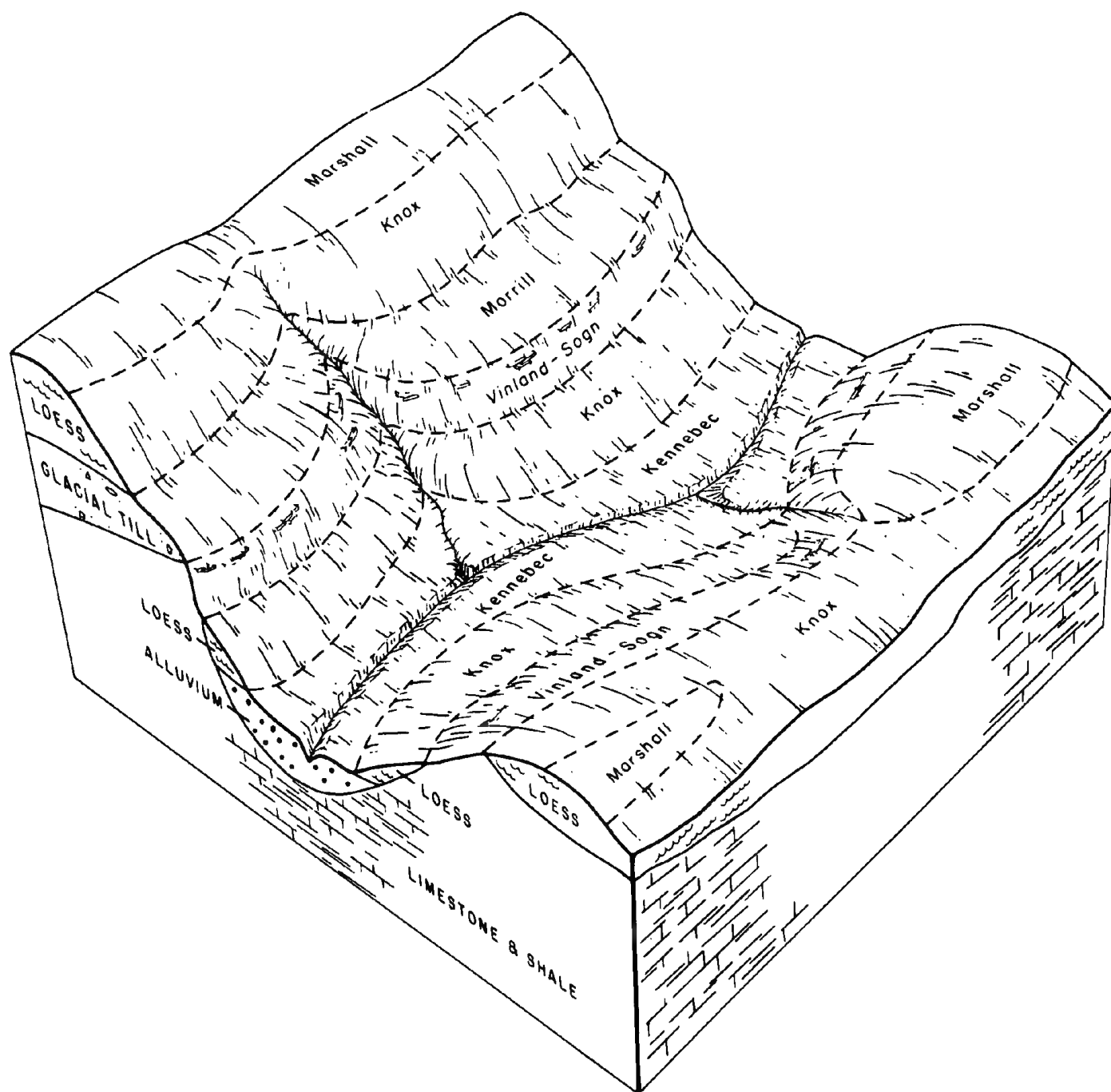


Figure 4.—Typical pattern of soils in the Knox-Marshall-Vinland association.

The moderately well drained Haynie soils formed in loamy alluvium. Typically, the surface layer is very dark grayish brown silt loam about 8 inches thick. The substratum to a depth of about 60 inches is stratified silt loam and very fine sandy loam. The upper part is dark

grayish brown, and the lower part is grayish brown, brown, and very dark gray.

The poorly drained Albaton soils formed in clayey alluvium. Typically, the surface layer is very dark gray silty clay about 8 inches thick. The substratum to a depth of

about 60 inches is stratified, very dark gray and dark grayish brown silty clay.

The minor soils in this association are Aquents and Colo and Sarpy soils. The Aquents are in borrow pits that were dug when the levees were constructed. The dark, silty Colo soils are along creeks entering the valley of the Missouri River. The sandy Sarpy soils are on narrow ridges.

This association is used mainly for cultivated crops. Some small areas along the Missouri River support trees. Corn, soybeans, grain sorghum, and small grain are the main cultivated crops. Fruit and vegetable crops are also grown. Controlling flooding, improving surface drainage, and maintaining tilth and fertility are concerns in managing the major soils.

This association has fair to good potential for cultivated crops, for pasture, and for openland wildlife habitat. It has fair to poor potential for woodland and poor potential for building site development and sanitary facilities.

8. Kennebec-Colo-Judson association

Deep, nearly level and gently sloping, moderately well drained, poorly drained, and well drained soils that have a silt loam and silty clay loam subsoil; on flood plains, terraces, and foot slopes

This association consists of nearly level soils on flood plains and gently sloping soils on terraces and foot slopes along Wolf River and Independence Creek. It makes up about 5 percent of the county. It is about 35 percent Kennebec soils, 32 percent Colo soils, 18 percent Judson soils, and 15 percent minor soils.

The moderately well drained Kennebec soils formed in silty alluvium on flood plains. Typically, the surface layer is black silt loam about 9 inches thick. The subsurface layer is black silt loam about 28 inches thick. The next 9 inches is very dark brown, mottled silt loam. The substratum to a depth of about 60 inches is dark grayish brown, mottled silt loam.

The poorly drained Colo soils formed in silty alluvium on flood plains. Typically, the surface layer is very dark grayish brown silt loam about 10 inches thick. The subsurface layer is silty clay loam about 24 inches thick. The upper part is black, and the lower part is very dark gray. The next 7 inches is very dark gray, mottled silty clay loam. The substratum to a depth of about 60 inches is dark gray and black, mottled silty clay loam.

The well drained Judson soils formed in silty alluvium on stream terraces and foot slopes. Typically, the surface layer is very dark brown silt loam about 8 inches thick. The subsurface layer is about 14 inches thick. The upper part is very dark brown silt loam, and the lower part is very dark grayish brown silty clay loam. The subsoil to a depth of about 60 inches is silty clay loam. The

upper part is dark brown, the middle part is dark yellowish brown, and the lower part is brown.

The minor soils in this association are Haynie, Knox, Marshall, and Reading soils. The calcareous Haynie soils are on the lower flood plains. The well drained Knox and Marshall soils are on side slopes. The moderately well drained Reading soils are on stream terraces.

This association is used mainly for cultivated crops. Some small areas are used for hay and pasture. Corn, soybeans, small grain, and grain sorghum are the main cultivated crops. Flooding is a hazard. Controlling flooding and maintaining fertility and tilth are concerns in managing the major soils.

This association has good potential for cultivated crops, for pasture, and for woodland. It has fair to good potential for openland and woodland wildlife habitat and poor potential for building site development and sanitary facilities.

Soil maps for detailed planning

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and management of the soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil, a brief description of the soil profile, and a listing of the principal hazards and limitations to be considered in planning the management for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying material, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Morrill loam, 2 to 7 percent slopes, eroded, is one of several phases in the Morrill series.

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils that occur as areas so intricately mixed or so small that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Haynie-Onawa complex is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. These dissimilar soils are described in each map unit. Also, some of the more unusual or strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes some *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Pits, quarries, is an example. Some miscellaneous areas are large enough to be delineated on the soil maps. Some that are too small to be delineated are identified by a special symbol on the soil maps.

The names and descriptions of the soils identified on the detailed soil maps for this county do not fully agree with those of the soils identified on the maps for adjacent counties. Differences result from a better knowledge of the soils, modifications in series concepts, a higher or lower intensity of mapping, and variations in the extent of the soils.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of tables") give properties of the soils and the limitations and capabilities for many uses. The Glossary defines many of the terms used in describing the soils.

Soil descriptions

Ab—Albaton silty clay. This nearly level, poorly drained soil is in depressional areas on the flood plains along the Missouri River. It is occasionally flooded. Individual areas are long or irregular in shape and range from 10 to 200 acres in size.

Typically, the surface layer is very dark gray silty clay about 8 inches thick. The substratum to a depth of about 60 inches is stratified, very dark gray and dark grayish brown silty clay. In places the dark surface layer is more than 10 inches thick.

Included with this soil in mapping are small areas of the somewhat poorly drained Onawa soils, which make up about 10 percent of the unit. These soils are loamy in the lower part of the substratum, which is at a depth of 16 to 30 inches. They are in the slightly higher lying areas.

Runoff is slow on the Albaton soil, and permeability is very slow. Available water capacity is moderate. The shrink-swell potential is high. Reaction is mildly alkaline or moderately alkaline throughout the soil. Natural fertility

is high. The surface layer is very firm and is difficult to till. The seasonal high water table is at a depth of 1 to 3 feet during the winter and spring.

Most areas are farmed. Some small areas are pastured. This soil has fair potential for cultivated crops and for hay, pasture, and wetland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is moderately well suited to corn, grain sorghum, small grain, soybeans, grasses, and legumes. Wetness and ponding are the main concerns of management. The soil is poorly drained and dries slowly. The wetness delays tillage, especially during rainy periods. Grain sorghum and soybeans can be planted later than corn. Wheat can usually be planted in the fall, but harvesting may be delayed by wetness. Surface ditches, surface bedding, and land smoothing and grading improve drainage. Crop residue management and timely tillage help to maintain fertility and tilth.

This soil is suited to pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Proper stocking rates and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the flooding is a severe hazard. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IIIw.

At—Aquents. These nearly level, poorly drained and very poorly drained soils are in borrow pits, where soil material has been removed for fill, mainly in building levees. They are frequently flooded. The pits vary in depth. The sides of some pits are nearly vertical. The areas occur as long, narrow tracts, mainly between the levees and the Missouri River.

The soils are dominantly loamy and clayey, but in some areas recently deposited sand covers the surface.

Included with these soils in mapping are small areas of Albaton, Haynie, Onawa, and Sarpy soils, which make up 10 to 15 percent of the unit. These included soils are in narrow undisturbed areas between the pits.

These soils have poor potential for most uses. Most areas are idle and are covered with brush and trees. Some are covered with a dense stand of willows and cottonwoods. Water covers most areas for short periods in most years. Some areas are used for cultivated crops grown primarily to control the brush and trees. The crops cannot be harvested because of the flooding and the deposition of sand.

These soils are generally unsuitable as sites for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the flooding is a severe hazard. Overcoming the flooding is difficult without major flood control measures.

These soils are not assigned to a capability class or subclass.

Co—Colo silt loam. This nearly level, poorly drained soil is on flood plains along the tributaries of the Missouri River. It is occasionally flooded. Individual areas are irregular in shape and range from 10 to 300 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 10 inches thick. The subsurface layer is black and very dark gray silty clay loam about 24 inches thick. The next 7 inches is very dark gray, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is dark gray and black, mottled silty clay loam. In places the soil is less clayey throughout. In some areas the upper 36 inches is browner.

Included with this soil in mapping are small areas of the more clayey Albaton soils in shallow depressions. These soils make up less than 5 percent of the unit.

Available water capacity is high in the Colo soil. Permeability is moderately slow, and runoff is slow. Natural fertility is high, and organic matter content is moderate. The surface layer is friable and can be easily tilled. Reaction is neutral or slightly acid throughout the soil. The seasonal high water table is at a depth of 1 to 3 feet. The shrink-swell potential is high.

Most areas are farmed. Some small tracts are pastured. This soil has good potential for cultivated crops and for hay, pasture, and wetland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. Floodwater, however, can damage crops. Crop residue management helps to maintain fertility and tilth.

This soil is suited to pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

Because the flooding is a severe hazard, this soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is 1lw.

Gb—Grundy silty clay loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on broad ridgetops. Individual areas are irregular in shape and range from 10 to 800 acres in size.

Typically, the surface soil is black silty clay loam about 13 inches thick. The subsoil is about 34 inches thick. The upper part is very dark brown, firm silty clay loam.

The middle part is very dark grayish brown and dark grayish brown, mottled, firm silty clay. The lower part is dark gray and grayish brown, mottled, firm silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled silty clay loam. In places the subsoil is less clayey.

Included with this soil in mapping are small areas of the well drained, less clayey Marshall and Morrill soils on the lower side slopes. These soils make up 10 to 15 percent of the unit.

Permeability is slow in the Grundy soil, and runoff is also slow. Available water capacity is moderate. Natural fertility is high. Reaction is medium acid or slightly acid in the subsoil and varies widely in the surface layer as a result of local liming practices. The shrink-swell potential is high. The surface layer is friable and can be easily tilled. The seasonal high water table is perched at a depth of 1 to 3 feet during the spring.

Most areas are farmed. Some small areas are pastured. This soil has good potential for cultivated crops and for hay, pasture, and woodland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is moderately well suited to grain sorghum, corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Wetness, however, may delay spring planting. Also, the soil is droughty during the summer because the clayey subsoil releases water slowly. Leaving crop residue on the surface improves water infiltration, reduces the runoff rate, and helps to prevent surface crusting and excessive soil loss. Shallow drainage ditches reduce wetness.

This soil is suited to pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The shrink-swell potential and the wetness are severe limitations if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by shrinking and swelling and by wetness. Grading helps to remove surface water. Frost action, the shrink-swell potential, and low strength are severe limitations if this soil is used as a site for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations.

This soil is suitable as a site for sewage lagoons. It is generally unsuitable, however, as a site for septic tank absorption fields because the slow permeability and the wetness are severe limitations.

The capability subclass is 1lw.

Gc—Grundy silty clay loam, 2 to 6 percent slopes. This gently sloping, somewhat poorly drained soil is on uplands. Individual areas are irregular in shape and range from 10 to 80 acres in size.

Typically, the surface soil is black silty clay loam about 11 inches thick. The subsoil is about 28 inches thick. The upper part is very dark brown, firm silty clay loam. The middle part is very dark grayish brown and dark grayish brown, mottled, firm silty clay. The lower part is dark gray, mottled, firm silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled silty clay loam. In places the subsoil is less clayey. In some areas where the upper part of the subsoil has been mixed with the surface soil by tillage, the surface layer is silty clay.

Included with this soil in mapping are small areas of Judson, Kennebec, Morrill, and Marshall soils. The silty, well drained Judson soils are on terraces along drainageways. The silty, moderately well drained Kennebec soils are on flood plains along drainageways. The well drained Marshall and Morrill soils are on the lower side slopes. They are less clayey than the Grundy soil. Seeps or other wet spots are in the areas of Morrill soils on the lower slopes along drainageways. Included soils make up 5 to 15 percent of the unit.

Permeability is slow in the Grundy soil, and runoff is medium. Available water capacity is moderate. Natural fertility is high. Reaction is medium acid or slightly acid in the subsoil and varies widely in the surface layer as a result of local liming practices. The shrink-swell potential is high. The surface soil is friable and can be easily tilled. The seasonal high water table is perched at a depth of 1 to 3 feet during the spring.

Most areas are farmed. This soil has good potential for cultivated crops and for hay, pasture, and woodland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is well suited to corn, soybeans, grain sorghum, and small grain and to grasses and legumes for pasture and hay. If cultivated crops are grown, erosion is a hazard. The soil is wet in the spring, but it is droughty in the summer because the clayey subsoil releases water slowly. The wetness delays planting in some years. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and improves water infiltration.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The shrink-swell potential and the wetness are severe limitations if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by shrinking and swelling and by wetness. The shrink-swell poten-

tial, low strength, and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations.

This soil is generally unsuitable as a site for septic tank absorption fields because the slow permeability and the wetness are severe limitations. The slope is a moderate limitation on sites for sewage lagoons. The less sloping included areas are better sites.

The capability subclass is 11e.

Ha—Hamburg silt loam, 25 to 50 percent slopes.

This moderately steep and steep, somewhat excessively drained soil is on plane and convex side slopes, most of which are dissected by deep drainageways. Individual areas are irregular in shape and range from 20 to 3,000 acres in size.

Typically, the surface layer is brown, calcareous silt loam about 4 inches thick. The next 7 inches is brown, strongly calcareous, very friable silt loam. The substratum to a depth of about 60 inches is dark yellowish brown and brown, strongly calcareous silt loam. In places the depth to lime is more than 20 inches.

Included with this soil in mapping are areas of the well drained, noncalcareous, less sloping Monona soils; small narrow areas of rock outcrop along bluffs; very steep areas; and narrow areas of the nearly level, well drained Judson and moderately well drained Kennebec soils along drainageways. Also included are small areas where gullies have formed. Included areas make up 10 to 15 percent of this unit.

Permeability is moderate in the Hamburg soil, and runoff is rapid. Available water capacity is high. Organic matter content and natural fertility are low. The surface layer is mildly alkaline or moderately alkaline.

Nearly all areas were formerly farmed or used for orchards. Most areas are now used for brome grass pasture. The rest support trees and shrubs. This soil has poor potential for cultivated crops and fair potential for hay and pasture, trees, and woodland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is best suited to pasture or range. The major concerns of management are erosion and the moderately steep and steep slope. In disturbed or unprotected areas, erosion is a hazard because of the highly erosive nature of the calcareous silt loam. A protective plant cover and ground mulch helps to prevent excessive soil losses and reduce the runoff rate. Overstocking and overgrazing reduce the protective plant cover and cause surface compaction and excessive runoff. Measures that control brush, proper stocking rates, uniform grazing distribution, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture or range and the soil in good condition. Controlled grazing and proper distribution of salt help to prevent the formation of paths and thus help to control erosion.

This soil is moderately well suited to trees. A few areas remain in native hardwoods. Erosion, equipment limitations, and seedling mortality are management concerns if trees are planted or harvested on this moderately steep and steep soil.

This soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the moderately steep and steep slope is a severe limitation.

The capability subclass is VIIe.

Hn—Haynie silt loam. This nearly level, moderately well drained soil is on flood plains along the Missouri River and along some upland drainageways. In most areas it is occasionally flooded, but in the areas between levees and the Missouri River, it is frequently flooded. Individual areas are long and irregular in shape and range from 10 to 400 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 8 inches thick. The substratum to a depth of about 60 inches is stratified, mottled silt loam and very fine sandy loam. The upper part is dark grayish brown, and the lower part is grayish brown, brown, and very dark gray. In places, the dark surface layer is more than 10 inches thick and the depth to calcareous material is more than 10 inches.

Included with this soil in mapping are small areas of the poorly drained Albaton soils and the somewhat poorly drained Onawa soils in depressions. These soils make up 2 to 10 percent of the unit.

Permeability is moderate in the Haynie soil, and runoff is slow. Reaction is mildly alkaline or moderately alkaline. Natural fertility is medium, and organic matter content is low. The surface layer is very friable and can be easily tilled. The seasonal high water table is perched at a depth of 4 to 6 feet during the growing season.

Most areas are farmed. Some small tracts are pastured. This soil has good potential for cultivated crops and for hay, pasture, trees, and openland and woodland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. Floodwater, however, can damage crops. Crop residue management helps to maintain fertility and tilth.

This soil is suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

Because the flooding is a severe hazard, this soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IIw.

Ho—Haynie-Onawa complex. This map unit dominantly consists of moderately well drained Haynie and somewhat poorly drained Onawa soils on flood plains along the Missouri River. These soils are nearly level. In most areas they are occasionally flooded, but in the areas between levees and the Missouri River, they are frequently flooded. The Onawa soil, which is in shallow depressions, is subject to ponding.

Individual areas range from 10 to 500 acres in size. They are 50 to 60 percent Haynie soil and 30 to 40 percent Onawa soil. The two soils generally occur as areas that are so narrow that mapping them separately is not practical.

Typically, the Haynie soil has a surface layer of very dark grayish brown silt loam about 8 inches thick. The substratum to a depth of about 60 inches is dark grayish brown and grayish brown, stratified, mottled silt loam and very fine sandy loam. In places the dark surface layer is more than 10 inches thick.

Typically, the Onawa soil has a surface layer of very dark grayish brown silty clay loam about 8 inches thick. The upper part of the substratum is dark grayish brown, mottled, firm silty clay, and the lower part to a depth of 60 inches is stratified, dark grayish brown, mottled, friable silt loam and very fine sandy loam.

Included with these soils in mapping are small areas of the poorly drained Albaton soils and the excessively drained Sarpy soils. The Albaton soils are in shallow depressions, and the Sarpy soils are on sandy ridges. Included soils make up 5 to 15 percent of the unit.

Permeability is moderate in the Haynie soil. It is slow in the upper part of the Onawa soil and moderate in the lower part. Runoff is slow on the Haynie soil. On the Onawa soil, surface drainage is poor because of slow runoff and ponding. The surface layer of the Haynie soil is very friable and can be easily tilled. That of the Onawa soil, however, is firm and is difficult to till because of the wetness and the somewhat clayey texture. The shrink-swell potential is high in the Onawa soil. The seasonal high water table is at a depth of 4 to 6 feet in the Haynie soil and 2 to 4 feet in the Onawa soil. Natural fertility is medium in both soils, and organic matter content is low or moderately low.

Most areas are farmed. Some small tracts are pastured. These soils have fair potential for cultivated crops and for hay and pasture. They have good to fair potential for openland wildlife habitat and poor potential for building site development and sanitary facilities.

These soils are suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. The wetness, however, is a limitation, and the

floodwater can damage crops. The Onawa soil is difficult to work because it is wet and subject to ponding. It dries slowly in the spring. As a result, tillage and harvest are delayed, especially during rainy periods. Surface ditches, surface bedding, and land grading and smoothing improve drainage. Crop residue management helps to maintain fertility and tilth.

These soils are suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soils in good condition.

The Haynie soil is suited to trees. A few small areas remain in native hardwoods. No hazards or limitations affect planting or harvesting.

These soils are generally unsuitable as sites for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the flooding is a severe hazard. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IIw.

Hs—Haynie-Sarpy complex. This map unit dominantly consists of moderately well drained Haynie and excessively drained Sarpy soils on flood plains along the Missouri River. These soils are undulating. In most areas they are occasionally flooded, but in the areas between levees and the Missouri River, they are frequently flooded. Individual areas are long and range from 10 to 200 acres in size. They are 50 to 65 percent Haynie soil and 30 to 40 percent Sarpy soil.

Typically, the Haynie soil has a surface layer of very dark grayish brown very fine sandy loam about 8 inches thick. The substratum to a depth of about 60 inches is dark grayish brown and grayish brown, stratified, mottled silt loam and very fine sandy loam. In places the dark surface layer is more than 10 inches thick.

Typically, the Sarpy soil has a surface layer of very dark grayish brown loamy fine sand about 5 inches thick. The substratum to a depth of 60 inches is grayish brown and dark grayish brown, stratified fine sand and loamy fine sand.

Included with these soils in mapping are small areas of the somewhat poorly drained Onawa soils in shallow depressions. These included soils make up 5 to 10 percent of the unit.

Permeability is moderate in the Haynie soil and rapid in the Sarpy soil. Available water capacity is high in the Haynie soil and low in the Sarpy soil. Runoff is slow on both soils. The seasonal high water table is at a depth of 4 to 6 feet in the Haynie soil. The surface layer of both soils is very friable and can be easily tilled. Organic matter content is low in both soils. Natural fertility is medium in the Haynie soil and low in the Sarpy soil. Reaction is mildly alkaline or moderately alkaline throughout both soils.

Most areas are farmed. These soils have fair potential for crops, for hay and pasture, for trees, and for open-

land and woodland wildlife habitat. They have poor potential for building site development and sanitary facilities.

These soils are suited to corn, grain sorghum, and small grain and to grasses and legumes for pasture and hay. The floodwater, however, can damage crops. Soil blowing and the low available water capacity are additional management concerns on the Sarpy soil. Crop residue management and a protective plant cover help to control soil blowing. Applications of fertilizer help to maintain fertility and tilth.

A cover of pasture grasses is effective in controlling soil blowing. Overstocking and overgrazing, however, reduce the protective plant cover and cause deterioration of the plants. Measures that control brush, proper stocking rates, uniform grazing distribution, and a planned grazing system help to keep the pasture or range in good condition and help to control soil blowing.

These soils are suited to trees. A few areas remain in native hardwoods. Selecting suitable species, preparing a site adequately, and controlling soil blowing help to obtain a good stand.

These soils are generally unsuitable as sites for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the flooding is a severe hazard. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IIw.

Ju—Judson silt loam, 1 to 3 percent slopes. This gently sloping, well drained soil is on foot slopes and stream terraces. Individual areas are irregular in shape and range from 10 to 100 acres in size.

Typically, the surface layer is very dark brown silt loam about 8 inches thick. The subsurface layer is about 14 inches thick. The upper part is very dark brown, friable silt loam, and the lower part is very dark grayish brown, friable silty clay loam. The subsoil to a depth of about 60 inches is friable silty clay loam. The upper part is dark brown, the middle part is dark yellowish brown, and the lower part is brown. In places the subsoil is very dark brown and black. In some areas the surface layer is less than 8 inches thick.

Included with this soil in mapping are small areas of the moderately well drained Reading soils. These soils are more clayey than the Judson soil. They are in the lower, more nearly level areas.

Available water capacity is high in the Judson soil, and permeability is moderate. Runoff is medium. The surface layer is friable and can be easily tilled. Natural fertility is high, and organic matter content is moderate. The upper part of the soil is slightly acid. The shrink-swell potential is moderate.

Most areas are farmed. Some small narrow tracts are pastured. This soil has good potential for cultivated crops, for hay, pasture, and trees, and for openland and woodland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, small grain, and grain sorghum and to grasses and legumes for hay and pasture. Crop residue management helps to maintain fertility and tilth. Diversion terraces help to control runoff from the higher adjoining side slopes.

This soil is suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is well suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

The shrink-swell potential is a moderate limitation if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations.

This soil is suitable as a site for septic tank absorption fields. Seepage is a moderate limitation, however, on sites for sewage lagoons. It can be controlled by sealing the lagoon.

The capability class is I.

Ke—Kennebec silt loam. This nearly level, moderately well drained soil is on flood plains along streams. It is occasionally flooded. Individual areas are long and range from 10 to 200 acres in size.

Typically, the surface layer is black silt loam about 9 inches thick. The subsurface layer is black, friable silt loam about 28 inches thick. The next 9 inches is very dark brown, friable, mottled silt loam. The substratum to a depth of about 60 inches is dark grayish brown, mottled silt loam. In places the soil is more clayey and is dark to a greater depth. In some areas the subsurface layer is browner.

Included with this soil in mapping are small areas of Reading soils on stream terraces. These soils have a more clayey subsoil than the Kennebec soil.

Available water capacity is high in the Kennebec soil. Permeability is moderate, and runoff is slow. Natural fertility is high, and organic matter content is moderate. The surface layer is friable and can be easily tilled. It is neutral to medium acid. The shrink-swell potential is moderate. The seasonal high water table is at a depth of 3 to 5 feet.

Most areas are farmed. Some small tracts are pastured. This soil has good potential for cultivated crops, for hay, pasture, and trees, and for openland and wood-

land wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. Floodwater, however, can damage crops. Crop residue management helps to maintain fertility and tilth.

This soil is suitable for pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

Because the flooding is a severe hazard, this soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IIw.

Kf—Kennebec silt loam, channeled. This nearly level, moderately well drained soil is on the sides of stream channels (fig. 5). It is frequently flooded. Individual areas are long and narrow and are continuous along some streams. They range from 30 to 200 acres in size.

Typically, the surface soil is black silt loam about 37 inches thick. The next 9 inches is very dark brown, friable, mottled silt loam. The substratum to a depth of about 60 inches is dark grayish brown, mottled silt loam. In some areas the surface soil is thinner or lighter colored.

Included with this soil in mapping are small areas of Haynie and Sarpy soils. These soils make up less than 10 percent of this unit. The calcareous Haynie soils are in the higher areas adjacent to the channels. The sandy Sarpy soils are in the low areas along the channels.

Permeability is moderate in the Kennebec soil, and available water capacity is high. Runoff is slow. Organic matter content is moderate, and natural fertility is high. The surface layer is medium acid to neutral. The shrink-swell potential is moderate. The seasonal high water table is at a depth of 3 to 5 feet.

Most areas support trees. This soil has poor potential for cultivated crops and for hay, building site development, and sanitary facilities because it is frequently flooded. It has fair potential for pasture and good potential for trees and for openland and woodland wildlife habitat.

Some small tracts are pastured. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing,



Figure 5.—A water-filled channel in an area of Kennebec silt loam, channeled.

and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees. Most areas remain in native hardwoods. Trees are generally needed for streambank stabilization. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

Because the flooding is a severe hazard, this soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is Vw.

Kn—Knox silt loam, 4 to 10 percent slopes, eroded. This moderately sloping, well drained soil is on

convex ridgetops and on side slopes below limestone ledges. Individual areas are irregular in shape and range from 10 to 400 acres in size.

Typically, the surface layer is dark brown silt loam about 8 inches thick. The upper part of the subsoil is dark yellowish brown, friable silty clay loam. The lower part to a depth of more than 60 inches is brown, friable, mottled silt loam. In some areas the surface layer is darker and is underlain by a lighter colored subsurface layer. It is brown silty clay loam in areas where it has been mixed with the upper part of the subsoil by plowing. In places the subsoil is more clayey.

Included with this soil in mapping are small areas of Hamburg, Monona, and Morrill soils. These soils make up about 15 percent of the unit. The Hamburg soils are on the steeper side slopes. Their surface layer is thinner than that of the Knox soil, and they lack a subsoil. The Monona soils are on the upper side slopes and on ridgetops. Their surface soil is thicker and darker than that of

the Knox soil. The Morrill soils are on the lower side slopes. They contain more sand and gravel throughout than the Knox soil. Also included are small areas where gullies have formed.

Available water capacity is high in the Knox soil. Permeability is moderate, and runoff is rapid. Natural fertility is medium, and organic matter content is low. The surface layer is medium acid or slightly acid. It is friable and can be easily tilled. The shrink-swell potential is moderate.

Most areas are farmed. This soil has fair potential for cultivated crops and good potential for pasture, for trees, and for openland and woodland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is moderately well suited to corn, soybeans, grain sorghum, and small grain. Further erosion is a hazard if cultivated crops are grown. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate.

This soil is suited to grasses and legumes for hay and pasture. A cover of grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, measures that control brush, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees. A few areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation, by prescribed burning, or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

The shrink-swell potential is a moderate limitation if this soil is used as a site for dwellings. Properly designing and reinforcing foundations can help to prevent the structural damage caused by the shrinking and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations. The soil is suitable as a site for septic tank absorption fields.

The capability subclass is IIIe.

Ko—Knox silt loam, 10 to 18 percent slopes, eroded. This strongly sloping, well drained soil is on convex ridgetops and side slopes. Individual areas are irregular in shape and range from 10 to 900 acres in size.

Typically, the surface layer is dark brown silt loam about 8 inches thick. The upper part of the subsoil is dark yellowish brown, friable silty clay loam. The lower part to a depth of more than 60 inches is brown, friable,

mottled silt loam. In some areas the surface layer is darker and is underlain by a lighter colored subsurface layer. It is brown silty clay loam in areas where it has been mixed with the upper part of the subsoil by plowing. In places the subsoil is more clayey.

Included with this soil in mapping are small areas of Hamburg, Monona, and Morrill soils. These soils make up about 15 percent of the unit. The Hamburg soils are on the steeper side slopes. Their surface layer is thinner than that of the Knox soil, and they lack a subsoil. The Monona soils are on the upper side slopes and on ridgetops. Their surface soil is thicker and darker than that of the Knox soil. The Morrill soils are on the lower side slopes. They contain more sand and gravel throughout than the Knox soil. Also included are small areas where gullies have formed.

Permeability is moderate in the Knox soil, and runoff is rapid. Available water capacity is high. Natural fertility is medium, and organic matter content is low. The surface layer ranges from strongly acid to slightly acid unless it has been limed. It is friable and can be easily tilled. The shrink-swell potential is moderate.

Most areas are farmed. This soil has fair potential for cultivated crops and good potential for pasture and hay, for trees, and for openland and woodland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, grain sorghum, and small grain and to grasses and legumes for hay and pasture. Further erosion is a hazard, however, if cultivated crops are grown. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Before the irregular or complex slopes in the steeper areas can be terraced, cutting and filling are needed. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, measures that control brush, and restricted use during wet periods help to keep the pasture and the soil in good condition. Controlled grazing and proper distribution of salt help to prevent the formation of paths and thus help to control erosion.

This soil is suited to trees. A few areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation, by prescribed burning, or by spraying, cutting, or girdling. Hazards and limitations are slight if trees are planted or harvested on this soil.

The shrink-swell potential and the slope are moderate limitations if this soil is used as a site for dwellings. Properly designing and reinforcing foundations can help to prevent the structural damage caused by the shrinking

and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations. The slope is a moderate limitation on sites for septic tank absorption fields. The septic tank system functions better if the design of the field overcomes the slope.

The capability subclass is IVe.

Kp—Knox silt loam, 18 to 30 percent slopes, eroded. This moderately steep, well drained soil is on strongly dissected slopes and bluffs along the valley of the Missouri River and its tributaries. Individual areas are irregular in shape and range from 10 to 1,200 acres in size.

Typically, the surface layer is dark brown silt loam about 6 inches thick. The upper part of the subsoil is dark yellowish brown, friable silty clay loam. The lower part to a depth of more than 60 inches is brown, friable, mottled silt loam. In some areas the surface layer is darker and is underlain by a lighter colored subsurface layer. It is brown silty clay loam in areas where it has been mixed with the upper part of the subsoil by plowing.

Included with this soil in mapping are small areas of Monona and Hamburg soils. These soils make up about 10 percent of the unit. The Monona soils are on the higher ridgetops. Their surface soil is thicker and darker than that of the Knox soil. The Hamburg soils are on the steeper bluffs. Their surface layer is thinner than that of the Knox soil, and they lack a subsoil. Also included are small areas where gullies have formed and small narrow areas of the Judson and Kennebec soils along drainageways.

Permeability is moderate in the Knox soil, and runoff is rapid. Available water capacity is high. Natural fertility is medium, and organic matter content is low. The surface layer and the upper part of the subsoil range from strongly acid to slightly acid. The surface layer is friable and can be easily tilled. The shrink-swell potential is moderate.

Most areas are used for range or pasture or support trees. Many areas are cultivated. This soil has good potential for range, hay, and pasture and for woodland wildlife habitat. It has fair potential for trees and poor potential for cultivated crops, building site development, and sanitary facilities.

This soil is best suited to range or pasture. The major concerns in managing range and pasture are erosion and control of brush and trees. A protective plant cover and ground mulch help to prevent excessive soil losses and improve the moisture supplying capacity by reducing the runoff rate. Overstocking or overgrazing the range reduces the protective plant cover and causes deterioration of the plant community. Measures that control brush, proper stocking rates, uniform grazing distribution, timely deferment of grazing, and a planned grazing system help to keep the range and the soil in good condition.

This soil is suited to trees. Some areas remain in native hardwoods. The erosion hazard, the equipment

limitation, and seedling mortality are moderate if trees are planted or harvested on this moderately steep soil.

This soil is generally unsuitable as a site for dwellings, septic tank absorption fields, and sewage lagoons because the slope is a severe limitation. Slope, low strength, and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome the low strength and frost action.

The capability subclass is VIe.

Ma—Marshall silt loam, 1 to 3 percent slopes. This gently sloping, well drained soil is on ridgetops. Individual areas are irregular in shape and range from 10 to 800 acres in size.

Typically, the surface layer is very dark brown silt loam about 7 inches thick. The subsoil is about 47 inches thick. The upper part is very dark grayish brown, friable silty clay loam; the middle part is dark brown and brown, friable silty clay loam; and the lower part is dark yellowish brown, friable, mottled silty clay loam. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam. In some places the subsoil is more clayey, and in other places it is less clayey.

Included with this soil in mapping are small areas of Judson, Kennebec, and Morrill soils. These soils make up 5 to 10 percent of the unit. The deep, dark colored Judson and Kennebec soils are along drainageways. The Morrill soils are on the lower side slopes. They contain sand and gravel throughout. Seeps or other wet spots are in the areas of Morrill soils.

Permeability is moderate in the Marshall soil, and runoff is medium. Available water capacity is high. Natural fertility is also high. Reaction ranges from medium acid to neutral in the subsoil and varies widely in the surface layer as a result of local liming practices. The shrink-swell potential is moderate. The surface layer is friable and can be easily tilled.

Most areas are farmed. This soil has good potential for cultivated crops, for hay and pasture, and for openland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, grain sorghum, and small grain and to grasses and legumes for pasture and hay. If cultivated crops are grown, erosion is a hazard. Terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The shrink-swell potential is a moderate limitation if this soil is used as a site for dwellings. Properly design-

ing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations. The soil is suitable as a site for septic tank absorption fields.

The capability subclass is IIe.

Mb—Marshall silt loam, 3 to 7 percent slopes. This moderately sloping, well drained soil is on convex side slopes. Individual areas are irregular in shape and range from 10 to 1,400 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsoil is about 47 inches thick. The upper part is very dark grayish brown, friable silty clay loam; the middle part is dark brown and brown, friable silty clay loam; and the lower part is dark yellowish brown, friable, mottled silty clay loam. The substratum to a depth of about 60 inches is dark yellowish brown, mottled silty clay loam. In some places the subsoil is more clayey, and in other places it is less clayey. The surface layer is silty clay loam in areas where it has been mixed with the upper part of the subsoil by plowing.

Included with this soil in mapping are small areas of Judson, Kennebec, and Morrill soils. These soils make up 10 to 15 percent of the unit. The deep, dark colored, nearly level or gently sloping Kennebec and Judson soils are along drainageways. The Morrill soils are on the lower side slopes. They contain sand and gravel throughout. Seeps and other wet spots are in the areas of Morrill soils.

Permeability is moderate in the Marshall soil, and runoff is rapid. Available water capacity is high. Natural fertility is also high. Reaction ranges from medium acid to neutral in the subsoil and varies widely in the surface layer as a result of local liming practices. The shrink-swell potential is moderate. The surface layer is friable and can be easily tilled.

Most areas are farmed. This soil has good potential for cultivated crops, for hay and pasture, and for openland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, grain sorghum, and small grain and to grasses and legumes for pasture and hay. If cultivated crops are grown, erosion is a hazard. Terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The shrink-swell potential is a moderate limitation if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations. The soil is suitable as a site for septic tank absorption fields.

The capability subclass is IIIe.

Mc—Martin silty clay loam, 3 to 7 percent slopes, eroded. This moderately sloping, moderately well drained soil is on foot slopes along drainageways. Individual areas are irregular in shape and range from 10 to 80 acres in size.

Typically, the surface layer is very dark brown silty clay loam about 7 inches thick. The subsoil is about 44 inches thick. The upper part is very dark gray, very firm silty clay; the middle part is very dark grayish brown, very firm, mottled silty clay; and the lower part is dark grayish brown and olive brown, very firm, mottled silty clay. Olive and pale olive shale is at a depth of about 51 inches. In some areas the surface layer is thicker and less clayey. It is silty clay in areas where it has been mixed with the upper part of the subsoil by plowing. In places the shale is within a depth of 40 inches.

Included with this soil in mapping are small areas of Morrill soils, which make up 10 to 15 percent of the unit. These soils are redder and less clayey than the Martin soil. They are on the upper side slopes. Also included are seeps or other areas that are periodically wet; reddish, clayey soils that formed in material weathered from interbedded limestone and shale; and small areas where gullies have formed.

Permeability is slow in the Martin soil. Available water capacity is moderate, and runoff is rapid. Natural fertility is medium. The shrink-swell potential is high. The upper part of the soil ranges from medium acid to neutral. The surface layer is firm and is difficult to till. Root penetration is restricted by the bedrock at a depth of about 51 inches.

Most areas are farmed. This soil has fair potential for cultivated crops and for trees. It has good potential for hay and pasture and for openland and rangeland wildlife habitat and poor potential for building site development and sanitary facilities.

This soil is moderately well suited to corn, soybeans, grain sorghum, and small grain. It is suited to grasses and legumes for pasture and hay. If cultivated crops are grown, further erosion is a hazard. Terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate. Subsurface tile is needed in the seepy or other wet areas.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is suited to trees. A few areas remain in native hardwoods. The slope is a moderate limitation in wooded areas.

The shrink-swell potential is a severe limitation if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength, the shrink-swell potential, and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations.

The slow permeability is a severe limitation if this soil is used as a site for septic tank absorption fields. Increasing the size of the absorption field improves the functioning of the septic tank system. The slope is a moderate limitation on sites for sewage lagoons. The less sloping included areas are better sites.

The capability subclass is IVe.

Md—Monona silt loam, 3 to 10 percent slopes. This moderately sloping, well drained soil is on convex ridgetops and side slopes. Individual areas are irregular in shape and range from 10 to 1,800 acres in size.

Typically, the surface soil is very dark brown silt loam about 14 inches thick. The subsoil is brown, friable silt loam about 16 inches thick. The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam. In places the subsoil is more clayey. The surface soil is lighter colored in areas where it has been mixed with the upper part of the subsoil by plowing.

Included with this soil in mapping are small areas of Knox and Morrill soils. These soils make up 5 to 10 percent of the unit. The Knox soils are on the lower side slopes. Their dark surface layer is thinner than that of the Monona soil, and the subsoil is more clayey. The Morrill soils are on the lower side slopes. They contain sand and gravel throughout and are redder than the Monona soil. Also included are seeps or other wet spots on the lower slopes along drainageways.

Permeability is moderate in the Monona soil, and runoff is medium. Available water capacity is high. Reaction ranges from medium acid to neutral in the subsoil and varies widely in the surface soil as a result of local liming practices. Natural fertility is high, and organic matter content is moderate. The surface soil is friable and can be easily tilled. The shrink-swell potential is moderate.

Most areas are farmed. This soil has good potential for cultivated crops, for hay and pasture, and for openland and woodland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, grain sorghum, and small grain and to grasses and legumes for pasture and hay. If cultivated crops are grown, erosion is a hazard. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The shrink-swell potential is a moderate limitation if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations. The soil is suitable as a site for septic tank absorption fields.

The capability subclass is IIIe.

Me—Monona silt loam, 3 to 10 percent slopes, eroded. This moderately sloping, well drained soil is on convex ridgetops and side slopes. Individual areas are irregular in shape and range from 10 to 1,000 acres in size.

Typically, the surface soil is very dark grayish brown silt loam about 11 inches thick. The subsoil is brown, friable silt loam about 14 inches thick. The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam. The surface soil is lighter colored in areas where it has been mixed with the upper part of the subsoil by plowing. In places it is darker. In some areas the subsoil is more clayey.

Included with this soil in mapping are small areas of Knox and Morrill soils. These soils make up 10 to 15 percent of the unit. The Knox soils are on the lower side slopes. Their dark surface layer is thinner than that of the Monona soil, and the subsoil is more clayey. The Morrill soils are on the lower side slopes. They contain sand and gravel throughout and are redder than the Monona soil. Also included are seep areas or other wet spots on the lower side slopes along drainageways, generally near the Morrill soils, and small areas where gullies have formed.

Permeability is moderate in the Monona soil, and runoff is medium. Available water capacity is high. Reaction ranges from medium acid to neutral in the subsoil and varies widely in the surface soil as a result of local liming practices. Natural fertility is medium. Organic matter content is moderately low because of the loss of

surface soil through erosion. The surface soil is friable and can be easily tilled. The shrink-swell potential is moderate.

Most areas are farmed. This soil has good potential for cultivated crops, for hay and pasture, and for openland and woodland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, grain sorghum, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, further erosion is a hazard. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The shrink-swell potential is a moderate limitation if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations. The soil is suitable as a site for septic tank absorption fields.

The capability subclass is IIIe.

Mf—Monona silt loam, 10 to 18 percent slopes, eroded. This strongly sloping, well drained soil is on convex side slopes. Individual areas are irregular in shape and range from 10 to 1,800 acres in size.

Typically, the surface soil is very dark grayish brown silt loam about 11 inches thick. The subsoil is brown, friable silt loam about 14 inches thick. The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam. The surface soil is lighter colored in about 20 to 40 percent of the areas, where it has been mixed with the upper part of the subsoil by plowing. In other areas it is darker. In places the subsoil is more clayey.

Included with this soil in mapping are small areas of Hamburg, Knox, and Morrill soils. These soils make up 10 to 15 percent of this unit. The Hamburg soils are on the steeper side slopes. Their surface layer is thinner and lighter colored than that of the Monona soil. The Knox soils are on the lower side slopes. Their dark surface layer is thinner than that of the Monona soil, and the subsoil is more clayey. The Morrill soils are on the lower side slopes. They are redder than the Monona soil and contain more sand and gravel throughout. Also included are small areas where gullies have formed.

Permeability is moderate in the Monona soil, and runoff is rapid. Available water capacity is high. Natural fertility is medium. Organic matter content is low because of the loss of surface soil through erosion. Reaction ranges from medium acid to neutral in the subsoil and varies widely in the surface soil as a result of local liming practices. The surface soil is friable and can be easily tilled. The shrink-swell potential is moderate.

Most areas are farmed. This soil has fair potential for most cultivated crops and good potential for pasture and hay and for openland and woodland wildlife habitat. It has fair potential for building site development and sanitary facilities.

This soil is suited to corn, grain sorghum, soybeans, and small grain and to grasses and legumes for hay and pasture if erosion is controlled. If cultivated crops are grown, further erosion is a hazard. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Before the irregular or complex slopes in the steeper areas can be terraced, extensive cutting and filling are needed. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition. Controlled grazing and proper distribution of salt help to prevent the formation of paths and thus help to control erosion.

The shrink-swell potential and the slope are moderate limitations if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations. The slope is a moderate limitation on sites for septic tank absorption fields and a severe limitation on sites for sewage lagoons.

The capability subclass is IVe.

Mh—Monona-Hamburg silt loams, 18 to 30 percent slopes, eroded. These moderately steep, well drained and somewhat excessively drained soils are on plane and convex side slopes and ridgetops. In most areas they are dissected by deep drainageways. Individual areas are irregular in shape and range from 10 to 1,100 acres in size. They are about 65 percent Monona soil and 25 percent Hamburg soil. The Hamburg soil is steeper and more eroded than the Monona soil.

Typically, the surface soil of the Monona soil is very dark grayish brown silt loam about 11 inches thick. The subsoil is brown, friable silt loam about 10 inches thick.

The substratum to a depth of about 60 inches is brown and dark yellowish brown, mottled silt loam. The surface soil is thinner and lighter colored in areas where it has been mixed with the upper part of the subsoil by plowing.

Typically, the surface layer of the Hamburg soil is brown, calcareous silt loam about 4 inches thick. The next 7 inches is brown, calcareous, friable silt loam. The substratum to a depth of about 60 inches is dark yellowish brown and brown, calcareous silt loam. In places the depth to lime is more than 20 inches.

Included with these soils in mapping are small narrow areas where rock ledges protrude along bluffs and on very steep parts of the landscape, narrow areas of Judson and Kennebec soils along drainageways, and small areas of Morrill soils on the lower side slopes. The Morrill soils are redder than the Monona and Hamburg soils. Also included are small areas where gullies have formed. Included areas make up about 10 percent of the unit.

Permeability is moderate in the Monona and Hamburg soils. Available water capacity is high, and runoff is rapid. Natural fertility is medium or low, and organic matter content is low. In disturbed or unprotected areas, erosion is a hazard because of the highly erosive nature of the calcareous silt loam. Deep, narrow gullies have formed in these areas. The surface soil of the Monona soil is slightly acid or neutral. The surface layer of the Hamburg soil is mildly alkaline or moderately alkaline. In places lime concretions are on the surface. The shrink-swell potential is moderate in the Monona soil.

Nearly all areas were formerly farmed or used for orchards. Many areas remain in cropland. These soils have poor potential for cultivated crops and good potential for hay, pasture, range, and trees. They have fair potential for openland and woodland wildlife habitat and poor potential for building site development and sanitary facilities.

Although much of the acreage is cultivated, these soils are generally unsuited to cultivated crops. The hazard of erosion is very severe on these moderately steep soils.

These soils are best suited to pasture and range. The major management concern is the hazard of erosion. A protective plant cover and ground mulch help to prevent excessive soil losses and reduce the runoff rate. Overstocking or overgrazing reduces the protective plant cover and causes surface compaction and excessive runoff. Measures that control brush, proper stocking rates, uniform distribution of grazing, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture or range and the soil in good condition. Controlled grazing and proper distribution of salt help to prevent the formation of paths and thus help to control erosion.

These soils are suited to trees. Some areas remain in native hardwoods. The erosion hazard, equipment limitations, and seedling mortality are moderate if trees are planted or harvested on the Hamburg soil.

These soils are generally unsuitable as sites for dwellings, septic tank absorption fields, and sewage lagoons

because the slope is a severe limitation. Slope and frost action are severe limitations on sites for local roads and streets. Also, low strength is a severe limitation in the Monona soil. Strengthening or replacing the base material helps to overcome the low strength and the frost action potential.

The capability subclass is Vle.

Mo—Morrill loam, 2 to 7 percent slopes, eroded.

This gently sloping, well drained soil is on side slopes. Individual areas are irregular in shape and range from 10 to 320 acres in size.

Typically, the surface layer is very dark grayish brown loam about 5 inches thick. The subsoil to a depth of about 60 inches is clay loam. The upper part is dark brown and friable, the middle part is reddish brown and firm, and the lower part is reddish brown and brown and firm. In places the subsoil is more clayey. In some areas the soil is less red. The surface layer is brown clay loam in 20 to 40 percent of the areas, where it has been mixed with the upper part of the subsoil by plowing. Glacial pebbles and rocks are on the surface in these areas.

Included with this soil in mapping are small areas of Grundy, Knox, and Marshall soils. These soils make up 10 to 15 percent of the unit. They are on the upper side slopes and on ridgetops. They are less sandy and less red than the Morrill soil. Also included are seep areas, which are periodically wet.

Permeability is moderately slow in the Morrill soil. Available water capacity is high, and runoff is medium. Natural fertility is medium, and organic matter content is moderately low. The surface layer is medium acid or slightly acid. It typically is friable and can be easily tilled. In the areas where it is clay loam, however, it is firm and difficult to till. The shrink-swell potential is moderate.

Most areas are farmed. This soil has fair potential for cultivated crops and good potential for hay and pasture and for openland and rangeland wildlife habitat. It has fair potential for building site development and poor potential for sanitary facilities.

This soil is suited to corn, soybeans, grain sorghum, and small grain and to grasses and legumes for hay and pasture. Further erosion is a hazard, however, if cultivated crops are grown. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface reduces the runoff rate, helps to control erosion, and increases the infiltration rate. Subsurface tile is needed in the seep areas.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The shrink-swell potential is a moderate limitation if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength is a severe limitation on sites for local roads and streets. Strengthening or replacing the base material helps to overcome this limitation.

The moderately slow permeability is a severe limitation if this soil is used as a site for septic tank absorption fields. Increasing the size of the absorption field improves the functioning of the septic tank system. The slope is a moderate limitation on sites for sewage lagoons. Less sloping areas are better sites.

The capability subclass is IIIe.

Mp—Morrill loam, 7 to 12 percent slopes, eroded.

This moderately sloping, well drained soil is on side slopes. Individual areas are irregular in shape and range from 10 to 180 acres in size.

Typically, the surface layer is very dark grayish brown loam about 5 inches thick. The subsoil to a depth of about 60 inches is clay loam. The upper part is dark brown and friable, the middle part is reddish brown and firm, and the lower part is reddish brown and brown and is firm. In places the subsoil is more clayey. In some areas the soil is less red. The surface layer is brown clay loam in 20 to 40 percent of the areas, where it has been mixed with the upper part of the subsoil by plowing. Glacial pebbles and rocks are on the surface in these areas.

Included with this soil in mapping are small areas of Knox, Marshall, and Martin soils. These soils make up 10 to 15 percent of the unit. The Knox and Marshall soils are on the upper side slopes and on ridgetops. They are less sandy and less red than the Morrill soil. The Martin soils are on foot slopes. They are more clayey than the Morrill soil. Also included are seep areas, which are periodically wet.

Permeability is moderately slow in the Morrill soil. Available water capacity is high, and runoff is rapid. Natural fertility is medium, and organic matter content is moderately low. The surface layer is medium acid or slightly acid. It typically is friable and can be easily tilled. In the areas where it is clay loam, however, it is firm and difficult to till. The shrink-swell potential is moderate.

Most areas are farmed. This soil has fair potential for cultivated crops and good potential for hay and pasture and for openland and rangeland wildlife habitat. It has fair potential for building site development and poor potential for sanitary facilities.

This soil is moderately well suited to soybeans, grain sorghum, and small grain. It is well suited to grasses and legumes for hay and pasture. Further erosion is a hazard if cultivated crops are grown. Minimum tillage, terraces, contour farming, crop residue management, and grassed waterways or underground tile outlets help to control runoff and erosion. Leaving crop residue on the surface

reduces the runoff rate, helps to control erosion, and increases the infiltration rate. Subsurface tile is needed in the seep areas.

A cover of pasture grasses is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

The slope and the shrink-swell potential are moderate limitations if this soil is used as a site for dwellings. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. Low strength is a severe limitation on sites for local roads and streets. Strengthening or replacing the base material helps to overcome this limitation.

The moderately slow permeability is a severe limitation if this soil is used as a site for septic tank absorption fields. Increasing the size of the absorption field improves the functioning of the septic tank system. The slope is a severe limitation on sites for sewage lagoons. The less sloping included soils are better sites.

The capability subclass is IVe.

Ms—Morrill loam, 12 to 18 percent slopes, eroded.

This strongly sloping, well drained soil is on side slopes. Individual areas are irregular in shape and range from 10 to 120 acres in size.

Typically, the surface layer is very dark grayish brown loam about 5 inches thick. The subsoil to a depth of about 60 inches is clay loam. The upper part is dark brown and friable, the middle part is reddish brown and firm, and the lower part is reddish brown and brown and is firm. In places the subsoil is more clayey or is browner. In some areas the surface layer is sandy loam, gravelly loam, or clay loam. Glacial pebbles and rocks are on the surface in these areas.

Included with this soil in mapping are small areas of Knox, Marshall, Martin, Sogn, and Vinland soils. These soils make up 10 to 15 percent of the unit. The Knox and Marshall soils are on the upper side slopes and on ridgetops. They are less sandy and less red than the Morrill soil. The shallow Sogn and Vinland soils are on the lower side slopes. The Martin soils are on foot slopes. They are more clayey than the Morrill soil. Also included are seep areas, which are periodically wet; small areas where gullies have formed; and small areas of sandy and gravelly soils.

Permeability is moderately slow in the Morrill soil. Available water capacity is high, and runoff is rapid. Natural fertility is low, and organic matter content is moderately low. The shrink-swell potential is moderate.

Most areas are farmed. This soil has poor potential for cultivated crops and good potential for hay and pasture and for rangeland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is best suited to pasture, hay, and range. The major management concern is the hazard of erosion. A protective plant cover and ground mulch help to prevent excessive soil losses and reduce the runoff rate. Overstocking or overgrazing reduces the protective plant cover and causes surface compaction and excessive runoff. Measures that control brush, proper stocking rates, uniform distribution of grazing, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture or range and the soil in good condition.

This soil is generally unsuitable as a site for dwellings, septic tank absorption fields, and sewage lagoons because the slope is a severe limitation. The moderately slow permeability is also a limitation if the soil is used as a septic tank absorption field. Low strength and slope are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome the low strength.

The capability subclass is VIe.

Od—Onawa loam. This nearly level, somewhat poorly drained soil is on flood plains along the Missouri River. In most areas it is occasionally flooded. In the areas between levees and the Missouri River, however, it is frequently flooded. It is frequently ponded in many areas. Individual areas are irregular in shape and range from 10 to 800 acres in size.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. Most of this loam was deposited during a flood in 1952. The subsurface layer is very dark grayish brown, firm silty clay loam about 7 inches thick. The upper part of the substratum is dark grayish brown, mottled, firm silty clay, and the lower part to a depth of about 60 inches is stratified, dark grayish brown, mottled very fine sandy loam, loam, and silt loam. In places the surface layer is fine sandy loam, loamy fine sand, or silty clay loam. In some areas it is lighter colored.

Included with this soil in mapping are small areas of the silty Haynie and the sandy Sarpy soils. These soils make up 10 to 15 percent of the unit. They are on low ridges. Also included are areas that have been plowed to a depth of about 40 inches. In these areas the soils are mixed.

Permeability is slow in the clayey layers and moderate in the loamy layers of the Onawa soil. Available water capacity is high. Natural fertility is medium. Reaction is mildly alkaline or moderately alkaline throughout the profile. The seasonal high water table is at a depth of 2 to 4 feet. The surface layer is friable and can be easily tilled. The shrink-swell potential is high.

Most areas are farmed. Some small areas are pastured. This soil has fair potential for cultivated crops, hay, and pasture and good potential for wetland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is moderately well suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes

for hay and pasture. Cultivated crops can be damaged as a result of the flooding and the wetness. This somewhat poorly drained soil dries slowly. The wetness delays tillage and harvest, especially during rainy periods. Surface ditches, surface bedding, and land grading and smoothing improve drainage. Crop residue management helps to maintain fertility and tilth.

This soil is moderately well suited to pasture. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the flooding is a severe hazard. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IIw.

On—Onawa silty clay loam. This nearly level, somewhat poorly drained soil is on flood plains along the Missouri River. It is occasionally flooded, and it is frequently ponded in many areas. Individual areas are irregular in shape and range from 10 to 800 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 8 inches thick. The upper part of the substratum is dark grayish brown, mottled, firm silty clay, and the lower part to a depth of about 60 inches is stratified, dark grayish brown, mottled very fine sandy loam and silt loam. In places the surface layer is lighter colored.

Included with this soil in mapping are small areas of Albaton and Haynie soils. These soils make up 10 to 15 percent of the unit. The poorly drained Albaton soils are in shallow depressions. The moderately well drained Haynie soils are in the higher areas. They are less clayey than the Onawa soil. Also included are slightly undulating areas of sandy overwash.

Permeability is slow in the upper part of the Onawa soil and moderate in the lower part. Runoff is slow or ponded. Available water capacity is high. Natural fertility is medium. Reaction is mildly alkaline or moderately alkaline throughout the profile. The seasonal high water table is at a depth of 2 to 4 feet. The surface layer is firm and difficult to till. The shrink-swell potential is high.

Most areas are farmed. Some small tracts are pastured. This soil has fair potential for cultivated crops, hay, and pasture and good potential for wetland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is moderately well suited to corn, soybeans, wheat, and grain sorghum and to grasses and legumes for hay and pasture. Cultivated crops can be damaged as a result of the flooding and the wetness. This somewhat poorly drained soil dries slowly. The wetness delays tillage and harvest, especially during rainy periods. Surface ditches, surface bedding, and land grading

and smoothing improve drainage. Crop residue management helps to maintain fertility and tilth.

This soil is moderately well suited to pasture. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Measures that control brush, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the flooding is a severe hazard. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IIw.

Pt—Pits, quarries. This map unit consists mainly of open excavations from which soil and underlying limestone and shale have been removed. In most areas it is on the bluffs along the Missouri River. It is steep in many areas, and vertical walls are common. In places many feet of soil material were removed before the rock was excavated. Included in mapping are the adjacent areas of excavated material.

This map unit is generally unsuitable for most uses because of the vertical walls and the rocks. Most of the limestone is used as riprap along the Missouri River. Some of the gravel, sand, and other soil material is used as material for roads.

This map unit is not assigned to a capability class or subclass.

Re—Reading silt loam. This nearly level, moderately well drained soil is on stream terraces. It is subject to rare flooding. Individual areas are irregular in shape and range from 10 to 200 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is very dark grayish brown, friable silt loam about 5 inches thick. The subsoil to a depth of about 60 inches is firm silty clay loam. The upper part is very dark grayish brown, the middle part is dark brown, and the lower part is brown. In places the subsurface layer is lighter colored.

Included with this soil in mapping are small depressional areas of the poorly drained Colo soils and small areas of the well drained Judson soils on foot slopes. The Colo soils are more clayey and the Judson soils less clayey than the Reading soil. They make up 5 to 10 percent of the unit.

Permeability is moderately slow in the Reading soil. Runoff is slow. Available water capacity is high. Natural fertility is also high, and organic matter content is moderate. Unless limed, the surface layer is slightly acid or medium acid. It is friable and can be easily tilled. The shrink-swell potential is moderate. The seasonal high water table is at a depth of 3.5 to 6 feet in winter and spring.

Most areas are farmed. Some small tracts are pastured. This soil has good potential for cultivated crops,

hay, pasture, and trees and for openland and woodland wildlife habitat. It has poor potential for building site development and sanitary facilities.

This soil is suited to corn, soybeans, small grain, and grain sorghum and to grasses and legumes for hay and pasture. Crop residue management helps to maintain fertility and tilth.

This soil is suited to pasture. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and the soil in good condition.

This soil is well suited to trees. A few small areas remain in native hardwoods. Tree seeds, cuttings, and seedlings can survive and grow well if competing vegetation is controlled or removed. Plant competition can be controlled by site preparation or by spraying, cutting, or girdling. No hazards or limitations affect planting or harvesting.

Flooding is a severe hazard if this soil is used as a site for dwellings. Overcoming the flooding is difficult without major flood control measures. Low strength and frost action are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome these limitations.

The moderately slow permeability and the wetness are severe limitations if this soil is used as a septic tank absorption field. Increasing the size of the absorption field and installing perimeter drains around the absorption field improve the functioning of the septic tank system. Seepage and wetness are moderate limitations on sites for sewage lagoons. They can be controlled by sealing the lagoon.

The capability class is I.

Sa—Sarpy loamy fine sand. This undulating, excessively drained soil is on long and narrow, hummocky ridges on flood plains along the Missouri River. In most areas it is occasionally flooded, but in the areas between levees and the Missouri River, it is frequently flooded. Individual areas range from 10 to 200 acres in size.

Typically, the surface layer is very dark grayish brown, calcareous loamy fine sand about 5 inches thick. The substratum to a depth of about 60 inches is grayish brown and dark grayish brown, stratified, calcareous fine sand and loamy fine sand. In places the surface layer is less sandy.

Included with this soil in mapping are small areas of the moderately well drained Haynie soils and the somewhat poorly drained Onawa soils. These soils are in the lower lying areas. They make up 10 to 15 percent of the unit.

Permeability is rapid in the Sarpy soil, and runoff is slow. Available water capacity is low. Natural fertility and organic matter content are also low. The surface layer is neutral to moderately alkaline. It is very friable and can be easily tilled.

About three-fourths of the areas support trees, and the rest are mainly pasture or cropland. This soil has fair potential for hay, pasture, and trees. It has poor potential for cultivated crops and for openland and woodland wildlife habitat, building site development, and sanitary facilities.

This soil is poorly suited to wheat and grain sorghum. If cultivated crops are grown, soil blowing, flooding, and drought are hazards. Leaving crop residue on the surface helps to control soil blowing.

A cover of pasture or range plants is effective in controlling soil blowing. Overstocking and overgrazing reduce the protective plant cover and cause deterioration of the plant community. Measures that control brush, proper stocking rates, uniform distribution of grazing, timely deferment of grazing, and a planned grazing system help to keep the pasture or range in good condition and help to control soil blowing.

Many areas remain in native hardwoods. This soil can support trees, but seedling survival is poor. Planting a cover crop and managing crop residue help to control soil blowing. Competing trees can be controlled by spraying, cutting, or girdling. No hazards or limitations affect harvesting.

This soil is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the flooding is a severe hazard. Overcoming the flooding is difficult without major flood control measures.

The capability subclass is IVs.

Vr—Vinland-Rock outcrop complex, 20 to 40 percent slopes. This map unit consists dominantly of Rock outcrop and a somewhat excessively drained Vinland soil. It is moderately steep and steep. The Vinland soil is on the lower side slopes and the Rock outcrop on the upper side slopes. Individual areas are irregular in shape and range from 10 to 60 acres in size. They are 40 to 60 percent Vinland soil and 20 to 40 percent Rock outcrop. The Vinland soil and Rock outcrop occur as areas so intricately mixed or so small that mapping them separately is not practical.

Typically, the Vinland soil has a surface layer of very dark brown silty clay loam about 8 inches thick. The subsoil is dark grayish brown, friable silty clay loam about 4 inches thick. The substratum is olive brown, friable silty clay loam. Weathered silty shale is at a depth of about 17 inches. In places the depth to shale is more than 20 inches.

The Rock outcrop is dominant in the higher lying areas. Vertical rock ledges are common. Limestone fragments range from 3 to 30 inches in diameter.

Included with the Vinland soil and the Rock outcrop in mapping are small areas of the deep Hamburg, Knox, Martin, Monona, and Morrill soils. These included soils make up 10 to 15 percent of the map unit. The Hamburg, Knox, and Monona soils are on the upper side slopes. The Martin soils are on foot slopes. Their subsoil

is more clayey than that of the Vinland soil. The Morrill soils are on the upper side slopes. They are redder than the Vinland soil.

Permeability is moderate in the Vinland soil, and runoff is very rapid. Available water capacity is very low. Fertility is medium. Reaction is slightly acid to mildly alkaline. The shrink-swell potential is moderate. Root penetration is restricted by the bedrock at a depth of about 17 inches.

Most areas support trees and shrubs. This map unit has poor potential for trees and cultivated crops and fair potential for pasture, range, and woodland wildlife habitat. It has poor potential for building site development and sanitary facilities.

The Vinland soil is suited to grasses. Productivity is limited, however, because this shallow soil is droughty. Slopes are too steep for tillage. In the areas of Rock outcrop, the use of equipment and the growth of plants are limited. A protective plant cover and ground mulch help to prevent excessive soil losses and reduce the runoff rate. Careful management of grazing is essential. Measures that control brush, proper stocking rates, and deferment of grazing help to keep the grasses and the soil in good condition.

This map unit is generally unsuitable as a site for dwellings, septic tank absorption fields, sewage lagoons, and local roads and streets because the slope is a severe limitation.

The capability subclass is VIIs.

Vs—Vinland-Sogn silty clay loams, 4 to 15 percent slopes. These soils are moderately sloping and strongly sloping and are somewhat excessively drained. The Vinland soil is on the lower side slopes, and the Sogn soil is on the upper side slopes. Individual areas are irregular in shape and range from 10 to 50 acres in size. They are 40 to 70 percent Vinland soil and 20 to 40 percent Sogn soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is not practical.

Typically, the Vinland soil has a surface layer of very dark brown silty clay loam about 8 inches thick. The subsoil is dark grayish brown, friable silty clay loam about 4 inches thick. The substratum is olive brown, friable silty clay loam. Weathered silty shale is at a depth of about 17 inches. In places the depth to shale is more than 20 inches.

Typically, the Sogn soil has a surface layer of very dark brown silty clay loam about 9 inches thick. Hard fractured limestone bedrock is at a depth of about 9 inches (fig. 6). In places the soil is redder.

Included with these soils in mapping are small areas of the deep Knox, Martin, and Morrill soils. These included soils make up 10 to 15 percent of the map unit. The well drained Knox soils are on the upper side slopes. The moderately well drained Martin soils are on foot slopes. The well drained Morrill soils are on the upper side slopes. They are redder than the Vinland and Sogn soils.

Permeability is moderate in the Vinland and Sogn soils, and runoff is rapid. Available water capacity is very low.

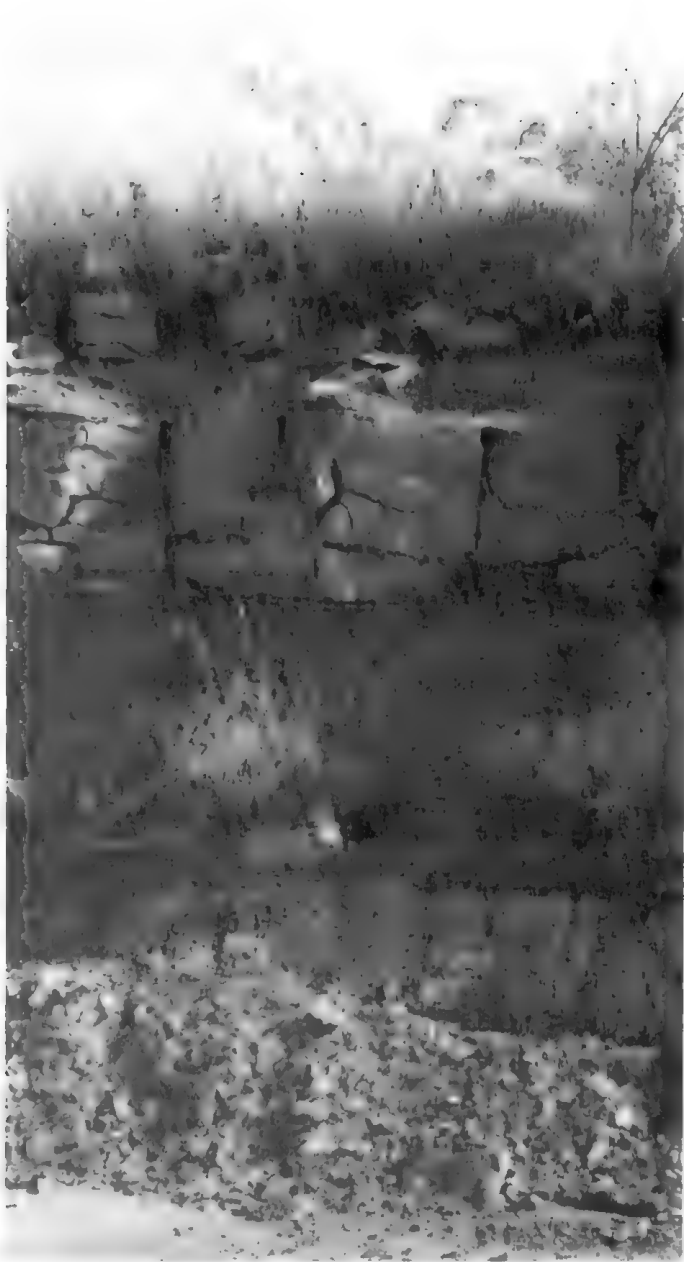


Figure 6.—Profile of Sogn silty clay loam. This soil is shallow over limestone bedrock.

Natural fertility is medium. In many areas, the underlying rock is fractured and roots can grow in the cracks. Reaction ranges from medium acid to mildly alkaline in the Vinland soil and from slightly acid to moderately alkaline in the Sogn soil. The shrink-swell potential is moderate in both soils. Root penetration is restricted by the bedrock at a depth of about 17 inches in the Vinland soil and 9 inches in the Sogn soil.

Most areas support native grasses and trees. These soils have good potential for range and pasture and poor potential for trees and cultivated crops. The potential for woodland wildlife habitat is fair on Vinland soil and is very poor on the Sogn soil. Both soils have poor potential for building site development and sanitary facilities.

These soils are suited to native grasses and to grasses and legumes for hay and pasture. The major concerns of management are erosion and the very low available water capacity. A protective plant cover and ground mulch help to prevent excessive soil losses and reduce the runoff rate. Measures that control brush, proper stocking rates, and deferment of grazing help to keep the range and pasture in good condition.

The depth to rock, the slope, and the shrink-swell potential are moderate limitations if the Vinland soil is used as a site for dwellings without basements. Properly designing and reinforcing foundations, installing foundation drains, and backfilling with porous material help to prevent the structural damage caused by the shrinking and swelling. The Sogn soil is generally unsuitable as a site for dwellings because the depth to rock is a severe limitation. The depth to rock in the Sogn soil and the low strength of the Vinland soil are severe limitations on sites for local roads and streets. Strengthening or replacing the base material helps to overcome the low strength.

These soils are generally unsuitable as sites for septic tank absorption fields and sewage lagoons because of the depth to rock. If feasible, sanitary facilities should be connected to commercial sewers and treatment facilities.

The capability subclass is VIe.

Use and management of the soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity

and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, and trees.

Crops and pasture

Earl J. Bondy, conservation agronomist, Soil Conservation Service, helped prepare this section.

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Soil maps for detailed planning." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

Crops

About 75 percent of the total land area in Doniphan County was cropland during the period 1967 to 1977. Corn was grown on 58 percent of this cropland, soybeans on 17 percent, grain sorghum on 11 percent, wheat on 10 percent, and alfalfa and oats on 4 percent. The acreage planted to soybeans during this period increased 71 percent, compared to the period 1957 to 1967. The acreage planted to corn increased 44 percent, and that planted to sorghum increased 3 percent. The acreage planted to other crops decreased.

Soil erosion is the major management concern on about 80 percent of the cropland and pasture in Doniphan County. It is a hazard if the slope is more than 2 percent (fig. 7). Nearly all the upland soils have slopes of more than 2 percent.

Loss of the surface layer through erosion is damaging because fertility is reduced when the less fertile subsoil or substratum is incorporated into a plow layer. On many sloping, eroded soils, productivity is reduced and harvesting difficult because small gullies have formed. Soil erosion also results in sediment entering streams. Control of erosion minimizes the pollution of streams and water impounding structures.

Crop residue management provides protective surface cover, reduces the runoff rate, and increases the infiltra-



Figure 7.—Serious erosion on Monona silt loam, 3 to 10 percent slopes, along a roadbank.

tion rate. Keeping a protective cover on the soil for an extended period helps to prevent losses through erosion

that reduce the productive capacity of the soils. On Knox, Monona, and Morrill soils a protective plant cover or a close-grown crop is needed unless erosion is controlled through minimum tillage.

Minimum tillage increases the infiltration rate, reduces the runoff rate, and helps to control erosion. It is practical on most soils in the survey area.

Terraces and diversions reduce the length of slopes and thus help to control runoff and erosion (fig. 8). They are most practical on deep, well drained soils that have regular slopes. Monona and Marshall soils are examples. Some soils are less suitable for terraces, diversions, and grassed waterways because they have steep and irregular slopes.

Contour farming helps to control erosion in many areas in the county. It is especially practical in areas that have been terraced.

In many areas underground tile outlets in combination with terraces are replacing grassed waterways (fig. 9). They can control erosion on the steeper, friable soils.

Soil drainage is a management concern on some soils on flood plains. Unless drained, the somewhat poorly drained Onawa soils and the poorly drained Albaton soils are so wet that crops are damaged. Artificial drainage is needed in some of the seepy areas adjacent to Colo, Judson, Kennebec, and Morrill soils.

Information concerning the design of erosion control measures and drainage systems for each kind of soil is contained in the Technical Guide, available in local offices of the Soil Conservation Service.

Soil fertility was naturally high in most soils in the uplands. Erosion, however, has reduced the organic matter content to medium or low. The Colo and Kennebec, and other soils on flood plains, which are dominantly slightly acid or neutral, are naturally higher in content of plant nutrients than most other soils. The Judson soils on terraces and foot slopes are also high in fertility. The upland soils that formed in silty loess are naturally high in content of phosphorus and potassium, but additions of chemical fertilizer are needed.

Many upland soils are medium acid. On these soils applications of lime may be needed to raise the pH level sufficiently for plants to grow well and for the chemical fertilizer to be effective. All additions of lime and fertilizer should be based on the results of soil tests, on the need of the crop, and on the expected level of yields.

Soil tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Most of the soils used for crops in the survey area have a silt loam surface layer that is moderately dark in color and moderate to low in content of organic matter. Generally, the structure of such soils is weak, and intense rainfall causes the formation of a crust on the surface. Once formed, the crust reduces the infiltration rate and increases the runoff rate. Regularly adding large amounts of crop residue or leaving large amounts on the surface improves the soil structure, helps to prevent surface crusting, and helps to control erosion. Minimum tillage helps to control erosion on the more sloping soils. Fall



Figure 8.—Plowed-up terraces on Monona silt loam.



Figure 9.—Terraces and tile outlets on Marshall silt loam.

plowing generally is not suitable on these soils because it results in extensive erosion.

Poor tilth is a problem on the clayey Albaton, Grundy, Martin, and Onawa soils, which stay wet for longer periods than other soils. If they are plowed or tilled when wet, they tend to be very cloddy when dry. As a result of the cloddiness, preparing a good seedbed is difficult. Fall plowing the more clayey bottom land soils results in good tilth in the spring.

Field crops suited to the soils in the county include many that are not now commonly grown. Corn is the main crop. Soybeans, grain sorghum, and wheat are also grown. Alfalfa, clover, barley, oats, and rye are other less extensively grown crops. They could be grown more extensively if economic conditions were favorable.

Special crops grown commercially in the survey area are some vegetables, small fruits, and tree fruits. Apples are the most important tree fruit grown in the county (fig. 10). Peaches are grown less extensively than in the past because of an unfavorable climate. Grapes and berries are the main small fruits. Vegetables and melons are grown in some areas.

The deep, well drained, Monona soils are well suited to vegetables and fruits. Soils in depressions and poorly drained soils are generally poorly suited to vegetables and fruits.

Pasture

About 10 percent of Doniphan County is pastured with cool season grasses, such as smooth brome, tall fescue, reed canarygrass, and orchardgrass. The pastures are in scattered areas throughout the county. Some are entirely tame grasses, and others are both tame and native grasses.

The main concerns in managing these areas are maintaining or improving the quality and quantity of forage, controlling erosion, and reducing water loss. Leaf development, root growth, flower-stalk formation, seed production, forage regrowth, and food storage in roots are concerns in obtaining maximum yields from forage plants.

Proper stocking rates help to keep the pasture in good condition. The number of livestock should be adjusted to the expected yield. Generally, about 40 pounds of forage per mature cow per day is needed for continuous seasonal grazing and 35 pounds for rotation grazing. Adjusting the number of livestock allows the pasture to provide forage for the entire grazing season.

Delaying grazing in the spring until the soil is dry and firm helps to prevent trampling and surface compaction. Deferred grazing during the midsummer dormancy of the grasses helps to maintain and improve the quality and

quantity of forage. Rotation grazing helps to prevent depletion of the pasture by allowing the grasses to recover after they have been grazed. Providing water and salt at a variety of locations results in a uniform distribution of grazing.

Applying fertilizer helps to keep the pasture in good condition. The kind and amount should be based on the results of soil tests and on field observations. Mowing a pasture that has been grazed unevenly or has an excess of forage and spraying a pasture with herbicides help to control invading trees, brush, low quality grasses, and broad-leaved weeds.

Yields per acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion

control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; and harvesting that insures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils.

Land capability classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the



Figure 10.—Apple orchard on Haynie-Onawa complex.

way they respond to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have slight limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w*, *s*, or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

Woodland management and productivity

James C. Geisler, area extension forester, Cooperative Extension Service, Kansas State University, helped prepare this section.

In 1965, a woodland resource inventory showed that Doniphan County had 37,700 acres of productive woodland, of which 4,000 acres was classified as "wooded strips" (3). These strips meet the national standards for commercial forest land, except that they are less than 120 feet wide. The strips, commonly along watercourses, generally support high value black walnut. All of the woodland is privately owned. About 10 percent is adequately treated, and about 30 percent should be either interplanted or reforested completely. On the rest, improvement of the timber stand generally is needed.

Only a small part of the woodland is managed for timber, which is used as lumber and veneer (fig. 11). Nearly all the woodland in the uplands is pastured. The bottom land along the Missouri River is used for grazing when the adjoining stubble fields are grazed. Some of the woodland provides food and cover for wildlife and areas for recreation. Native sugar maples add a blaze of color in the fall.

One major firm that logs and processes black walnut operates a log yard in the county. The entire processing facility for another firm is just across the Missouri River. Also, two small sawmills make pallets in the county.

Table 6 can be used by woodland owners or forest managers in planning the use of soils for wood crops. Only those soils suitable for wood crops are listed. The terms *slight*, *moderate*, and *severe* indicate the degree of the major soil limitations to be considered in management.

Ratings of the *erosion hazard* indicate the risk of loss of soil in well managed woodland. The risk is *slight* if the expected soil loss is small, *moderate* if measures are needed to control erosion during logging and road construction, and *severe* if intensive management or special equipment and methods are needed to prevent excessive loss of soil.

Ratings of *equipment limitation* reflect the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. A rating of *slight* indicates that use of equipment is not limited to a particular kind of equipment or time of year; *moderate* indicates a short seasonal limitation or a need for some modification in management or in equipment; and *severe* indicates a seasonal limitation, a need for special equipment or management, or a hazard in the use of equipment.

Seedling mortality ratings indicate the degree to which the soil affects the mortality of tree seedlings. Plant competition is not considered in the ratings. The ratings apply to seedlings from good stock that are properly planted during a period of sufficient rainfall. A rating of *slight* indicates that the expected mortality is less than 25 percent; *moderate*, 25 to 50 percent; and *severe*, more than 50 percent.



Figure 11.—Walnut trees on Kennebec silt loam. The trees provide timber for high quality veneer.

Ratings of *windthrow hazard* are based on the soil characteristics that affect the development of tree roots and the ability of the soil to hold trees firmly. A rating of *slight* indicates that a few trees may be blown down by normal winds; *moderate*, that some trees will be blown down during periods of excessive soil wetness and strong winds; and *severe*, that many trees are blown down during periods of excessive soil wetness and moderate or strong winds.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade where there are openings in the tree canopy. The invading plants compete with native plants or planted seedlings. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; *severe* indicates that plant competition is expected to prevent the establishment of a

desirable stand unless the site is intensively prepared, weeded, or otherwise managed to control undesirable plants.

The *potential productivity* of merchantable or *common trees* on a soil is expressed as a *site index*. This index is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands. Commonly grown trees are those that woodland managers generally favor in intermediate or improvement cuttings. They are selected on the basis of growth rate, quality, value, and marketability.

Trees to plant are those that are suited to the soils and to commercial wood production.

Recreation

Robert J. Higgins, biologist, Soil Conservation Service, helped prepare this section.

Recreation facilities in Doniphan County are somewhat limited. Swimming pools, picnic areas, and ballfields are the main facilities available to the general public. Farm ponds, streams, and the Missouri River provide opportunities for recreation on privately owned land (fig. 12).

The potential for recreational development is limited by the steep slopes. Many areas are not easily traversed

because they are cut by deep ravines and are excessively steep. Erosion in these areas and the resulting siltation of lakes and ponds reduce the potential for development of water impoundments.

The soils of the survey area are rated in table 7 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 7, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are



Figure 12.—Farm pond in an area of Marshall silt loam, 3 to 7 percent slopes. The pond can be used for fishing and the surrounding area for picnicking.

minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 7 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 10 and interpretations for dwellings without basements and for local roads and streets in table 9.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking, horseback riding, and bicycling should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Wildlife habitat

Robert J. Higgins, biologist, Soil Conservation Service, helped prepare this section.

Doniphan County provides a suitable habitat for many kinds of wildlife. The most important game species are bobwhite quail, mourning dove, fox squirrel, cottontail rabbit, and white-tailed deer. Ponds are used by migrating waterfowl. Fish inhabit the private water impoundments and the rivers and streams.

Nongame species are numerous because the types of habitat are diverse. Cropland, woodland, and grassland

are interspersed throughout the county. Each of these habitat types provides a home for a particular group of species. Furbearers are common along the Wolf and Missouri Rivers and their tributaries. They are trapped on a limited basis.

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 8, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, grain sorghum, wheat, and soybeans. *Grasses and legumes* are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, brome grass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil proper-

ties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, indiagrass, goldenrod, ragweed, wheatgrass, native legumes, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, cottonwood, black walnut, hackberry, willow, green ash, and hickory. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, fragrant sumac, plum, Nanking cherry, winterberry, and crabapple.

Coniferous plants furnish browse, seeds, and cones. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are redcedar, pine, and spruce.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, and foliage. Soil properties and features that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and soil moisture. Examples of shrubs are gooseberry, dogwood, blackberry, prairie rose, and sumac.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, cattails, saltgrass, and prairie cordgrass and rushes, sedges, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include bobwhite, pheasant, meadowlark, field sparrow, and cottontail.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wild-

life attracted to these areas include wild turkey, owls, woodcock, thrushes, woodpeckers, squirrels, gray fox, opossum, raccoon, and deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, muskrat, mink, and beaver.

Habitat for rangeland wildlife consists of areas of shrubs and wild herbaceous plants. Wildlife attracted to rangeland include coyote, white-tailed deer, badger, hawk, meadowlark, and dove.

Technical assistance in planning wildlife areas and in determining suitable species of vegetation for planting can be obtained from the Soil Conservation Service, the Kansas Fish and Game Commission, and the Cooperative Extension Service.

Engineering

Lawrence E. Robins, civil engineer, Soil Conservation Service, helped prepare this section.

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds

of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building site development

Table 9 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil.

The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

Sanitary facilities

Table 10 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 10 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features,

and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to effectively filter the effluent. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 10 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 10 are based on soil properties, site features, and observed performance of the soils.

Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction materials

Table 11 gives information about the soils as a source of construction materials. The soils are rated *good*, *fair*, *poor*, or *unsuited* as a source of roadfill, sand, gravel, and topsoil. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of

excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material and few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 11, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a good source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to

40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water management

Table 12 gives information on the soil properties and site features that affect water management. The kind of soil limitations are given for pond reservoir areas and embankments, dikes, and levees. The restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways also are given.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

In the areas of Hamburg, Monona, and other soils that formed in loess, the depth of ravines and low shear strength are special problems when earthen dams are designed and built. Many of the ravines are cut more than 30 feet below the valley floor. As a result, cutting core trenches is difficult, the amount of fill needed is increased, and longer metal pipes through the structure are needed. The Hamburg and Monona soils are suscep-

tible to piping and erosion, especially in the steeper areas.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances, such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are

made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering index properties

Table 13 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil series and morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains particles coarser than sand, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system (2) and the system adopted by the American Association of State Highway and Transportation Officials (1).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as Pt. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content

of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 3 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and plasticity index (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

Physical and chemical properties

Table 14 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of

each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to soil blowing in cultivated areas. The groups indicate the suscepti-

bility of soil to soil blowing and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control soil blowing are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control soil blowing are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control soil blowing are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control soil blowing are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control soil blowing are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to soil blowing.

Soil and water features

Table 15 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep

or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary inundation of an area, is caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt and water in swamps and marshes are not considered flooding.

Table 15 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as *none*, *rare*, *common*, *occasional*, and *frequent*. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs on an average of once or less in 2 years; and *frequent* that it occurs on an average of more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding.

Also considered is local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 15 are the depth to the seasonal high water table; the kind of water table—that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 15.

An apparent water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An artesian water table is under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A perched water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Only saturated zones within a depth of about 6 feet are indicated. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

Depth to bedrock is given if bedrock is within a depth of 5 feet. The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either rippable or hard. If the rock is rippable or fractured, excavations generally can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavations.

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured clayey soils that have a high water table in winter are most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Soil series and morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the Soil Survey Manual (5). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (6). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Soil maps for detailed planning."

Albaton series

The Albaton series consists of deep, poorly drained, very slowly permeable soils that formed in clayey alluvium. These soils are on flood plains along the Missouri River. Slopes range from 0 to 2 percent.

Albaton soils are commonly adjacent to Onawa soils. These adjacent soils have layers of silt loam and very fine sandy loam below a depth of 18 to 30 inches. They are slightly higher on the landscape than Albaton soils.

Typical pedon of Albaton silty clay, 1,050 feet south and 750 feet west of the northeast corner of sec. 36, T. 1 S., R. 19 E.

Ap—0 to 8 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; massive; extremely hard, very firm; slight effervescence; mildly alkaline; gradual wavy boundary.

C1g—8 to 60 inches; stratified very dark gray (10YR 3/1) and dark grayish brown (2.5Y 4/2) silty clay; common fine distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles; horizontal cleavage plane between strata forming some very coarse platy structure, some of which parts to moderate and strong fine angular blocky; very hard, very firm; slight and strong effervescence; mildly alkaline.

The solum is 6 to 9 inches thick. Most pedons are calcareous at or near the surface.

The A horizon has hue of 10YR or 2.5Y, value of 3, and chroma of 1 or 2. It is dominantly silty clay, but the range includes silty clay loam. The Cg horizon has hue of 2.5Y, 5Y, or 10YR, value of 3 to 5, and chroma of 0 to

2. It is silty clay or clay. In some pedons thin silty strata are below a depth of 48 inches.

Colo series

The Colo series consists of deep, poorly drained, moderately slowly permeable soils on flood plains. These soils formed in noncalcareous silty alluvium. Slopes range from 0 to 2 percent.

Colo soils are similar to Judson and Kennebec soils and are adjacent to those soils. The well drained Judson soils are on terraces and foot slopes. The moderately well drained Kennebec soils are on flood plains.

Typical pedon of Colo silt loam, 1,000 feet north and 900 feet east of the southwest corner of sec. 8, T. 2 S., R. 20 E.

Ap—0 to 10 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; many pores; neutral; clear smooth boundary.

A12—10 to 17 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; few very fine dark brown (10YR 3/3) mottles; weak fine granular structure; hard, friable; many pores; many worm casts; neutral; clear smooth boundary.

A13—17 to 23 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; few very fine distinct dark brown (10YR 3/3) mottles; weak medium prismatic structure parting to weak fine subangular blocky; hard, friable; many pores; slightly acid; gradual smooth boundary.

A14—23 to 34 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; few very fine distinct brown (10YR 4/3) mottles; weak fine subangular blocky structure; hard, friable; few pores; slightly acid; gradual smooth boundary.

ACg—34 to 41 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; many very fine distinct brown (10YR 4/3) mottles; weak very fine subangular blocky structure; hard, friable; few pores; neutral; gradual smooth boundary.

C1g—41 to 53 inches; dark gray (10YR 4/1) silty clay loam, gray (10YR 5/1) dry; common very fine distinct dark brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; very hard, firm; neutral; gradual smooth boundary.

C2g—53 to 60 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; many very fine faint dark gray (10YR 4/1) and dark yellowish brown (10YR 3/4) mottles; weak fine blocky structure; very hard, firm; neutral.

The solum ranges from 36 to 50 inches in thickness. The mollic epipedon is more than 36 inches thick.

The Ap horizon is recent overwash material. It has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. It is dominantly silt loam, but it is silty clay loam in some

pedons. It ranges from 8 to 16 inches in thickness. The part of the A horizon below the overwash material has hue of 10YR, value of 2 or 3, and chroma of 0 or 1. It averages as low as 27 percent clay in some pedons and as high as 35 percent clay in others. Some pedons are more clayey below a depth of 36 inches.

Grundy series

The Grundy series consists of deep, somewhat poorly drained, slowly permeable soils on loess covered uplands. Slopes range from 0 to 6 percent.

The mollic epipedon in the Grundy soils in this survey area is thicker than is defined as the range for the Grundy series. Also, it has distinct mottles in the lower part. These differences, however, do not alter the use or behavior of the soils.

Grundy soils are commonly adjacent to Knox, Marshall, and Morrill soils. All of these adjacent soils are less clayey than the Grundy soils. The Knox soils lack a mollic epipedon. They are on foot slopes. The Marshall soils lack an argillic horizon. They are on upland side slopes. The Morrill soils are redder than the Grundy soils and have more sand in the argillic horizon. They are on the lower side slopes.

Typical pedon of Grundy silty clay loam, 0 to 2 percent slopes, 2,350 feet east and 2,600 feet south of the northwest corner of sec. 30, T. 4 S., R. 19 E.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine granular structure; hard, friable; slightly acid; abrupt smooth boundary.

A12—8 to 13 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate medium granular structure; hard, friable; medium acid; gradual smooth boundary.

B1—13 to 19 inches; very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) dry; few very fine faint brown (10YR 4/3) mottles; strong fine subangular blocky structure; hard, firm; medium acid; gradual smooth boundary.

B21t—19 to 25 inches; very dark grayish brown (10YR 3/2) silty clay, gray (10YR 5/1) dry; common very fine faint dark yellowish brown (10YR 4/4) mottles; strong medium prismatic structure parting to moderate very fine blocky; very hard, firm; few very fine dark concretions; slightly acid; gradual smooth boundary.

B22t—25 to 30 inches; dark grayish brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) dry; many medium distinct dark yellowish brown (10YR 4/4) and prominent yellowish red (5YR 4/6) mottles; weak fine blocky structure; very hard, firm; few fine dark concretions; slightly acid; gradual smooth boundary.

B3—30 to 47 inches; dark gray (10YR 4/1) and grayish brown (10YR 5/2) silty clay loam; few medium prominent yellowish red (5YR 4/6) mottles; weak

very fine blocky structure; very hard, firm; few fine dark concretions; slightly acid; gradual smooth boundary.

C—47 to 60 inches; grayish brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) dry; many fine prominent yellowish red (5YR 5/6 and 4/6) mottles; massive; hard, firm; few fine dark concretions; neutral.

The thickness of the solum and the depth to lime are more than 40 inches. The mollic epipedon ranges from 11 to 33 inches in thickness.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silt loam. The B2t horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 to 3. It ranges from strongly acid to neutral. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 or 2.

Hamburg series

The Hamburg series consists of deep, somewhat excessively drained, moderately permeable soils on uplands. These soils formed in calcareous silty loess. Slopes range from 20 to 50 percent.

Hamburg soils are commonly adjacent to Knox and Monona soils on side slopes. They are more sloping than those soils. The Knox soils have an argillic horizon. Their dark surface layer is thicker than that of the Hamburg soil. The Monona soils have a mollic epipedon.

Typical pedon of Hamburg silt loam, 25 to 50 percent slopes, 3,000 feet north and 300 feet east of the southwest corner of sec. 14, T. 2 S., R. 20 E.

A1—0 to 4 inches; brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak very fine granular structure; slightly hard, very friable; strong effervescence; mildly alkaline; clear smooth boundary.

AC—4 to 11 inches; brown (10YR 4/3) silt loam, light yellowish brown (10YR 6/4) dry; weak very fine granular structure; slightly hard, very friable; few snail shells; strong effervescence; mildly alkaline; diffuse smooth boundary.

C1—11 to 47 inches; dark yellowish brown (10YR 4/4) silt loam, light yellowish brown (10YR 6/4) dry; massive; soft, very friable; few snail shells; strong effervescence; mildly alkaline; diffuse smooth boundary.

C2—47 to 60 inches; brown (10YR 5/3) silt loam, very pale brown (10YR 7/3) dry; massive; soft, very friable; few snail shells; strong effervescence; moderately alkaline.

The solum ranges from 6 to 20 inches in thickness. Lime is at or near the surface, and reaction is mildly alkaline or moderately alkaline throughout the profile.

The A horizon has hue of 10YR, value of 3 or 4, and chroma of 2 or 3. The A1 horizon is less than 6 inches

thick. The C horizon has hue of 10YR, value of 4 to 6, and chroma of 3 or 4. In some pedons strong brown, yellowish brown, and light brownish gray mottles are below a depth of 20 inches.

Haynie series

The Haynie series consists of deep, moderately well drained, moderately permeable soils that formed in loamy alluvium. These soils are on flood plains along the Missouri River and in upland drainageways. Slopes range from 0 to 3 percent.

Haynie soils are commonly adjacent to Albaton, Onawa, and Sarpy soils. The Albaton soils are more clayey than the Haynie soils. They are in shallow depressions. The Onawa soils are clayey in the upper part of the control section. They are on flood plains. The Sarpy soils are more sandy than the Haynie soils. They are on ridges.

Typical pedon of Haynie silt loam, 2,700 feet east and 1,750 feet south of the northwest corner of sec. 31, T. 1 S., R. 20 E.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; massive; slightly hard, very friable; slight effervescence; mildly alkaline; clear smooth boundary.

C1—8 to 22 inches; dark grayish brown (10YR 4/2) silt loam with thin strata of very fine sandy loam, light brownish gray (10YR 6/2) dry; common medium distinct strong brown (7.5YR 5/6) mottles; massive; hard, very friable; slight effervescence; moderately alkaline; clear smooth boundary.

C2—22 to 40 inches; dark grayish brown (10YR 4/2) very fine sandy loam with thin strata of silt loam, light brownish gray (10YR 6/2) dry; few medium distinct yellowish brown (10YR 5/6) mottles; massive; hard, very friable; strong effervescence; moderately alkaline; clear smooth boundary.

C3—40 to 60 inches; stratified grayish brown (10YR 5/2) and brown (10YR 5/3) silt loam and very fine sandy loam with thin very dark gray (10YR 3/1) clayey strata; common medium distinct strong brown (7.5YR 5/6) mottles; massive; slightly hard, very friable; strong effervescence; moderately alkaline.

The thickness of the solum is 6 to 9 inches and is the same as that of the Ap or A1 horizon. The depth to lime ranges from 0 to 10 inches.

The A horizon ranges from silt loam to very fine sandy loam. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 2 to 4. Many pedons are mottled with strong brown, yellowish brown, dark yellowish brown, reddish brown, or gray.

Judson series

The Judson series consists of deep, well drained, moderately permeable soils on foot slopes and terraces

along drainageways. These soils formed in silty alluvium. Slopes range from 1 to 3 percent.

Judson soils are similar to Colo and Kennebec soils and are commonly adjacent to Marshall and Monona soils. The Colo and Kennebec soils lack a B horizon. They are on flood plains. Also, the Colo soils are poorly drained. The Marshall and Monona soils typically are steeper than the Judson soils and are higher on the landscape. Their mollic epipedon is thinner than that of the Judson soils.

Typical pedon of Judson silt loam, 1 to 3 percent slopes, 1,750 feet east and 250 feet north of the southwest corner of sec. 27, T. 2 S., R. 20 E.

- Ap—0 to 8 inches; very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; slightly acid; clear smooth boundary.
- A12—8 to 13 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate fine granular structure; hard, friable; many pores; slightly acid; gradual smooth boundary.
- A13—13 to 22 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; hard, friable; many pores; slightly acid; gradual smooth boundary.
- B1—22 to 31 inches; dark brown (10YR 3/3) silty clay loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; slightly acid; gradual smooth boundary.
- B2—31 to 41 inches; dark yellowish brown (10YR 3/4) silty clay loam, yellowish brown (10YR 5/4) dry; moderate fine granular structure; hard, friable; neutral; gradual smooth boundary.
- B3—41 to 60 inches; brown (10YR 4/3) silty clay loam, pale brown (10YR 6/3) dry; weak medium subangular blocky structure; hard, friable; neutral.

The solum ranges from 40 to 60 inches in thickness. The mollic epipedon is more than 24 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silt loam, but the range includes silty clay loam. The B horizon averages as low as 30 percent clay in some pedons and as high as 35 percent clay in others. It has hue of 10YR and value and chroma of 3 or 4. In some pedons the B horizon and the C horizon, if it occurs, are mottled with dark yellowish brown, yellowish brown, or strong brown. The B horizon is medium acid to neutral and the C horizon slightly acid or neutral.

Kennebec series

The Kennebec series consists of deep, moderately well drained, moderately permeable soils on flood plains. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Kennebec soils are similar to Judson and Colo soils and are commonly adjacent to Marshall, Monona, and

Reading soils. The Judson soils have a B horizon. They are on foot slopes and terraces. The Colo soils are poorly drained and are on flood plains. The Marshall and Monona soils are on side slopes. Their mollic epipedon is thinner than that of the Kennebec soils. The Reading soils have an argillic horizon. They are on terraces.

Typical pedon of Kennebec silt loam, 1,600 feet west and 50 feet north of the southeast corner of sec. 36, T. 3 S., R. 20 E.

- Ap—0 to 9 inches; black (10YR 2/1) silt loam, very dark gray (10YR 3/1) dry; massive; slightly hard, friable; medium acid; clear smooth boundary.
- A12—9 to 21 inches; black (10YR 2/1) silt loam, very dark gray (10YR 3/1) dry; weak fine granular structure; slightly hard, friable; many pores; neutral; gradual smooth boundary.
- A13—21 to 37 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine granular structure; hard, friable; many pores; neutral; gradual smooth boundary.
- AC—37 to 46 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; common fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine granular structure; hard, friable; neutral; gradual smooth boundary.
- C1—46 to 60 inches; dark grayish brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) dry; common fine distinct dark yellowish brown (10YR 4/4) mottles; massive; hard, friable; many pores; neutral.

The solum and the mollic epipedon are more than 36 inches thick. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. Some pedons have a layer of dark grayish brown (10YR 4/2) overwash. The C horizon has hue of 10YR, value of 2 to 4, and chroma of 1 to 3. It is silt loam or silty clay loam.

Knox series

The Knox series consists of deep, well drained, moderately permeable soils on loess covered uplands. Slopes range from 4 to 30 percent.

Knox soils are commonly adjacent to Hamburg and Monona soils. The Hamburg soils are on the upper side slopes. They lack an argillic horizon, and their A horizon is thinner than that of the Knox soils. The Monona soils have a mollic epipedon that is more than 10 inches thick and lack an argillic horizon. They are on the higher ridgetops.

Typical pedon of Knox silt loam, 10 to 18 percent slopes, eroded, 1,850 feet east and 120 feet south of the northwest corner of sec. 19, T. 4 S., R. 21 E.

- Ap—0 to 8 inches; dark brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; massive; slightly hard, friable; medium acid; clear smooth boundary.
- B2t—8 to 34 inches; dark yellowish brown (10YR 4/4) silty clay loam, pale brown (10YR 6/3) dry; moder-

ate medium subangular blocky structure; hard, friable; thin discontinuous clay films; slightly acid; gradual smooth boundary.

B31—34 to 53 inches; dark yellowish brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; weak medium subangular blocky structure; hard, friable; thin discontinuous clay films; slightly acid; diffuse smooth boundary.

B32—53 to 60 inches; brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; few fine and medium distinct grayish brown (10YR 5/2) mottles; weak fine subangular blocky structure; hard, friable; slightly acid.

The solum ranges from 36 to more than 60 inches in thickness. The mollic epipedon is 6 to 9 inches thick.

The A horizon has hue of 10YR, value of 3, and chroma of 2 or 3. It is dominantly silt loam, but the range includes silty clay loam. Some pedons have an A2 horizon, which has hue of 10YR, value of 4 or 5, and chroma of 2 or 3. The B2 horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 to 6. The darker colors are in the upper part. This horizon is silt loam or silty clay loam that ranges from 25 to 35 percent clay. Many pedons are mottled with grayish brown or yellowish brown. The B horizon ranges from slightly acid to strongly acid.

Marshall series

The Marshall series consists of deep, well drained, moderately permeable soils on loess covered uplands. Slopes range from 1 to 7 percent.

Marshall soils are similar to Monona soils and are commonly adjacent to Grundy, Judson, Knox, and Morrill soils. The Monona soils typically are steeper than the Marshall soils and are lower on the landscape. Their A and B horizons contain less clay than those of Marshall soils. The Grundy soils have a clayey argillic horizon. They are on loess covered uplands. The Judson soils are on foot slopes and terraces. Their A horizon is thicker than that of Marshall soils. The Knox soils lack a mollic epipedon and have an argillic horizon. They are steeper than the Marshall soils and are lower on the landscape. The Morrill soils are redder than the Marshall soils and contain more sand in the argillic horizon. They are on the lower side slopes.

Typical pedon of Marshall silt loam, 3 to 7 percent slopes, 1,700 feet south and 100 feet west of the northeast corner of sec. 27, T. 4 S., R. 19 E.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; slightly hard, friable; slightly acid; clear smooth boundary.

B1—7 to 13 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure; hard, friable; neutral; gradual smooth boundary.

B22—13 to 21 inches; dark brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; moderate fine subangular blocky structure; hard, friable; slightly acid; gradual smooth boundary.

B23—21 to 33 inches; brown (10YR 4/3) silty clay loam, light yellowish brown (10YR 6/4) dry; weak fine subangular blocky structure; hard, friable; slightly acid; gradual smooth boundary.

B3—33 to 54 inches; dark yellowish brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; common fine faint yellowish brown (10YR 5/8) mottles; weak fine subangular blocky structure; hard, friable; slightly acid; gradual smooth boundary.

C1—54 to 60 inches; dark yellowish brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; few fine faint yellowish brown (10YR 5/8) mottles; massive; hard, friable; neutral.

The solum ranges from 40 to 60 inches in thickness. The mollic epipedon ranges from 10 to 18 inches in thickness.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2. It is dominantly silt loam, but the range includes silty clay loam. The B horizon has hue of 10YR, value of 3 or 4, and chroma of 2 to 4. It averages as low as 27 percent clay in some pedons and as high as 35 percent clay in others. It ranges from medium acid to neutral. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 6. It is silt loam or silty clay loam.

Martin series

The Martin series consists of deep, moderately well drained, slowly permeable soils on foot slopes. These soils formed in material weathered from shale. Slopes range from 3 to 7 percent.

Martin soils are commonly adjacent to Morrill, Sogn, and Vinland soils on the upper side slopes. The Morrill soils have a mollic epipedon that is thinner than that of the Martin soils, and they are redder than the Martin soils. The Sogn soils are less than 20 inches deep over limestone. The Vinland soils are less than 20 inches deep over shale.

Typical pedon of Martin silty clay loam, 3 to 7 percent slopes, eroded, 2,100 feet west and 250 feet south of the northeast corner of sec. 5, T. 4 S., R. 19 E.

Ap—0 to 7 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; hard, firm; few fine rock fragments; medium acid; clear smooth boundary.

B21t—7 to 16 inches; very dark gray (10YR 3/1) silty clay, dark grayish brown (10YR 4/2) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium blocky structure; extremely hard, very firm; few fine rock fragments; slightly acid; gradual smooth boundary.

B22t—16 to 27 inches; very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) dry; few fine faint yellowish brown (10YR 5/6) mottles; vertical streaks of very dark brown (10YR 2/2); weak very fine blocky structure; extremely hard, very firm; few fine rock fragments; few fine black concretions; mildly alkaline; diffuse smooth boundary.

B23t—27 to 43 inches; dark grayish brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) dry; common fine distinct olive yellow (2.5Y 6/6) mottles; weak very fine blocky structure; extremely hard, very firm; few fine black concretions; soft lime films and salt crystals in the lower part; mildly alkaline; diffuse smooth boundary.

B3—43 to 51 inches; olive brown (2.5Y 4/4) silty clay, light brownish gray (2.5Y 6/2) dry; common fine faint brownish yellow (10YR 6/6) mottles; weak fine subangular blocky structure; extremely hard, very firm; mildly alkaline; clear smooth boundary.

Cr—51 to 60 inches; olive (5Y 5/3) and pale olive (5Y 6/3) shale; moderately alkaline.

The thickness of the solum and the depth to shale are more than 40 inches. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silty clay. The B horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 to 4. The darker colors are in the upper part. The C horizon, if it occurs, has variegated colors ranging in hue from 5YR to 2.5Y.

Monona series

The Monona series consists of deep, well drained, moderately permeable soils on uplands. These soils formed in calcareous silty loess. Slopes range from 3 to 30 percent.

Monona soils are similar to Marshall soils and are commonly adjacent to Hamburg, Knox, and Morrill soils. The Marshall soils are on ridgetops. Their B horizon is more clayey than that of the Monona soils. The Hamburg soils lack a mollic epipedon. They are steeper than the Monona soils and are on side slopes. The Knox soils lack a mollic epipedon and have an argillic horizon. They are on the lower side slopes. The Morrill soils are redder than the Monona soils, and they have an argillic horizon. They are on the lower side slopes.

Typical pedon of Monona silt loam, 10 to 18 percent slopes, eroded, 2,350 feet north and 2,500 feet east of the southwest corner of sec. 18, T. 1 S., R. 19 E.

Ap—0 to 6 inches; very dark grayish brown (10YR 3/2) silt loam, brown (10YR 5/3) dry; massive; slightly hard, friable; medium acid; clear smooth boundary.

A3—6 to 11 inches; very dark grayish brown (10YR 3/2) silt loam, brown (10YR 5/3) dry; weak fine granular structure; slightly hard, friable; medium acid; gradual smooth boundary.

B2—11 to 25 inches; brown (10YR 4/3) silt loam, yellowish brown (10YR 5/4) dry; moderate fine granular structure; slightly hard, friable; slightly acid; clear smooth boundary.

C1—25 to 53 inches; brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; few fine faint yellowish brown (10YR 5/6) and grayish brown (10YR 5/2) mottles; massive; slightly hard, friable; neutral; diffuse smooth boundary.

C2—53 to 60 inches; dark yellowish brown (10YR 4/4) silt loam, light yellowish brown (10YR 6/4) dry; few fine faint grayish brown (10YR 5/2) mottles; massive; slightly hard, friable; neutral; few lime concretions in the lower part.

The solum ranges from 24 to 40 inches in thickness. The mollic epipedon ranges from 10 to 18 inches in thickness.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2. It is medium acid or slightly acid. The B horizon has hue of 10YR, value of 4 or 5, and chroma of 3 or 4. It is silt loam or silty clay loam that ranges from 24 to 31 percent clay. It is slightly acid or neutral. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 3 to 6. It has few to many, fine to coarse mottles with hue of 10YR, 2.5Y, or 5Y, value of 5 or 6, and chroma of 1 or 2 or with hue of 7.5YR, 10YR, 2.5Y, or 5Y, value of 5 or 6, and chroma of 6 to 8. It is neutral to moderately alkaline.

Morrill series

The Morrill series consists of deep, well drained, moderately slowly permeable soils on uplands. These soils formed in till or outwash deposited by retreating glaciers. Slopes range from 2 to 18 percent.

Morrill soils are commonly adjacent to Knox, Marshall, Martin, and Monona soils. They are redder than the adjacent soils. The Knox soils are on the upper side slopes. They lack a mollic epipedon. Their argillic horizon contains less sand than that of the Morrill soils. The Marshall and Monona soils lack an argillic horizon. They are on the upper side slopes. The Martin soils are on foot slopes. Their argillic horizon contains less sand than that of the Morrill soils.

Typical pedon of Morrill loam, 7 to 12 percent slopes, eroded, 1,100 feet north and 400 feet west of the southeast corner of sec. 19, T. 2 S., R. 19 E.

Ap—0 to 5 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; slightly hard, friable; slightly acid; clear smooth boundary.

B1—5 to 11 inches; dark brown (10YR 3/3) clay loam, brown (10YR 5/3) dry; weak fine granular structure; hard, friable; medium acid; gradual smooth boundary.

B21t—11 to 19 inches; dark brown (7.5YR 4/4) clay loam, brown (7.5YR 5/4) dry; vertical streaks of very

dark grayish brown (10YR 3/2); weak fine subangular blocky structure; hard, friable; medium acid; gradual smooth boundary.

B22t—19 to 28 inches; reddish brown (5YR 4/3) clay loam, reddish brown (5YR 5/3) dry; weak fine subangular blocky structure; very hard, firm; medium acid; gradual smooth boundary.

B23t—28 to 54 inches; reddish brown (5YR 4/4) clay loam, light brown (7.5YR 6/4) dry; weak medium subangular blocky structure; very hard, firm; few fine chert fragments; slightly acid; gradual smooth boundary.

B3—54 to 60 inches; reddish brown (5YR 4/4) and brown (7.5YR 5/4) clay loam; weak fine subangular blocky structure; very hard, firm; few fine chert fragments; few fine lime concretions; neutral.

The thickness of the solum is more than 30 inches. The mollic epipedon ranges from 10 to 20 inches in thickness.

The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 to 3. It is dominantly loam, but the range includes clay loam. The B1 horizon has hue of 10YR to 5YR, value of 3 or 4, and chroma of 2 or 3. It is clay loam or loam. The B2t horizon has hue of 7.5YR or 5YR, value of 3 or 4, and chroma of 3 to 5. In some pedons it has common mottles of a higher chroma. The B3 horizon and the C horizon, if it occurs, have hue of 10YR to 5YR, value of 4 or 5, and chroma of 3 to 6.

Onawa series

The Onawa series consists of deep, somewhat poorly drained soils that are slowly permeable in the upper part and moderately permeable in the lower part. These soils formed in calcareous clayey and loamy alluvium on flood plains. Slopes are 0 to 1 percent.

Onawa soils are commonly adjacent to Albaton and Haynie soils. The Albaton soils are clayey throughout. They are in shallow depressions. The Haynie soils are less clayey in the upper part than the Onawa soils. Also, they are slightly higher on the landscape.

Typical pedon of Onawa silty clay loam, 1,550 feet south and 250 feet east of the northwest corner of sec. 31, T. 1 S., R. 20 E.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak medium blocky structure; very hard, firm; slight effervescence; moderately alkaline; clear smooth boundary.

C1g—8 to 22 inches; dark grayish brown (10YR 4/2) silty clay, light brownish gray (10YR 6/2) dry; few fine distinct dark yellowish brown (10YR 4/6) mottles; weak medium subangular blocky structure; hard, firm; slight effervescence; moderately alkaline; clear smooth boundary.

C2g—22 to 26 inches; dark grayish brown (2.5Y 4/2) silty clay, grayish brown (10YR 5/2) dry; common

fine distinct dark yellowish brown (10YR 4/6) mottles; moderate medium blocky structure; very hard, firm; slight effervescence; moderately alkaline; clear smooth boundary.

II C3g—26 to 52 inches; dark grayish brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; few medium distinct strong brown (7.5YR 5/6) mottles; massive; slightly hard, friable; slight effervescence; moderately alkaline; clear smooth boundary.

II C4g—52 to 60 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; many fine distinct yellowish brown (10YR 5/6) mottles; massive; very hard, firm; slight effervescence; moderately alkaline.

Reaction is mildly alkaline or moderately alkaline throughout the profile. The A horizon has hue of 10YR or 2.5Y, value of 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes loam and silty clay. The silty clay control section ranges from 18 to 30 inches in thickness. The C and II C horizons have hue of 10YR, 2.5Y, or 5Y, value of 4 or 5, and chroma of 2 or less. In some pedons the C2g horizon occurs as very thin strata of silt loam, loam, very fine sandy loam, clay loam, and silty clay loam. The II C horizon is silt loam or very fine sandy loam.

Reading series

The Reading series consists of deep, moderately well drained, moderately slowly permeable soils on stream terraces. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Reading soils are commonly adjacent to Colo, Kennebec, and Knox soils. The Colo and Kennebec soils are on flood plains. Their mollic epipedon is thinner than that of the Reading soils, and they lack an argillic horizon. The Knox soils lack a mollic epipedon. Typically, they are steeper than the Reading soils and are higher on the landscape.

Typical pedon of Reading silt loam, 1,625 feet south and 75 feet east of the center of sec. 29, T. 4 S., R. 20 E.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; slightly hard, friable; medium acid; clear smooth boundary.

A12—9 to 14 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; moderate fine granular structure; slightly hard, friable; medium acid; clear smooth boundary.

B1—14 to 21 inches; very dark grayish brown (10YR 3/2) silty clay loam, brown (10YR 5/3) dry; weak fine subangular blocky structure; hard, firm; medium acid; gradual smooth boundary.

- B21t—21 to 30 inches; very dark grayish brown (10YR 3/2) silty clay loam, brown (10YR 5/3) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; moderate medium subangular blocky structure; very hard, firm; medium acid; gradual smooth boundary.
- B22t—30 to 46 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; common fine faint dark yellowish brown (10YR 4/4) mottles; weak medium subangular blocky structure; very hard, firm; slightly acid; gradual smooth boundary.
- B3—46 to 60 inches; brown (10YR 4/3) silty clay loam, pale brown (10YR 6/3) dry; common medium faint yellowish brown (10YR 5/6) mottles; moderate fine granular structure; hard, firm; slightly acid.

The solum is more than 50 inches thick. The mollic epipedon is more than 24 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silt loam, but the range includes silty clay loam. The B2 horizon has hue of 10YR, value of 3 or 4, and chroma of 2 to 4. It is silt loam or silty clay loam and generally averages as low as 28 percent clay in some pedons and as high as 35 percent clay in others. Below the control section, it averages about 38 percent clay. It is medium acid or slightly acid. The C horizon, if it occurs, has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 to 4 and has gray to reddish brown mottles. It is silty clay loam or light silty clay. It is slightly acid to moderately alkaline.

Sarpy series

The Sarpy series consists of deep, excessively drained, rapidly permeable soils on flood plains. These soils formed in calcareous sandy alluvium along the Missouri River. Slopes range from 1 to 5 percent.

Sarpy soils are commonly adjacent to Haynie and Onawa soils. The Haynie soils are more silty throughout than the Sarpy soils. The Onawa soils are clayey in the upper part.

Typical pedon of Sarpy loamy fine sand, 1,500 feet east and 200 feet north of the southwest corner of sec. 31, T. 3 S., R. 23 E.

- Ap—0 to 5 inches; very dark grayish brown (10YR 3/2) loamy fine sand, dark grayish brown (10YR 4/2) dry; massive; soft, very friable; slight effervescence; moderately alkaline; clear smooth boundary.
- C1—5 to 54 inches; stratified grayish brown (10YR 5/2) and dark grayish brown (10YR 4/2) fine sand, light gray (2.5Y 7/2) dry; massive; soft, very friable; slight effervescence; moderately alkaline; gradual smooth boundary.
- C2—54 to 60 inches; grayish brown (10YR 5/2) loamy fine sand, light gray (2.5Y 7/2) dry; few fine distinct yellowish brown (10YR 5/6) mottles; massive; soft, very friable; slight effervescence; moderately alkaline.

The solum is less than 10 inches thick. Free lime is at or near the surface. Reaction is neutral to moderately alkaline throughout the profile.

The A horizon has hue of 10YR, value of 3 to 5, and chroma of 1 to 3. It is dominantly loamy fine sand, but the range includes fine sand and fine sandy loam. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. It is dominantly fine sand or loamy fine sand, but in some pedons it has thin strata of finer textured material.

Sogn series

The Sogn series consists of very shallow and shallow, somewhat excessively drained, moderately permeable soils on uplands. These soils formed in material weathered from limestone. Slopes range from 0 to 15 percent.

Sogn soils are commonly adjacent to Knox, Martin, Morrill, and Vinland soils. The Knox, Martin, and Morrill soils are deeper than the Sogn soils. They have an argillic horizon. The Knox and Morrill soils are on the upper side slopes, and the Martin soils are on foot slopes. The Vinland soils have weathered shale within 20 inches of the surface. They are on the lower side slopes.

Typical pedon of Sogn silty clay loam, in an area of Vinland-Sogn silty clay loams, 4 to 15 percent slopes, about 1,100 feet west and 40 feet north of the center of sec. 29, T. 4 S., R. 20 E.

- A1—0 to 9 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; hard, friable; few fragments of weathered limestone; mildly alkaline; abrupt smooth boundary.

R—9 inches; fractured bedded limestone; narrow cracks filled with dark soil.

The thickness of the solum and the depth to hard limestone range from 4 to 20 inches. The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 to 3. It ranges from slightly acid to moderately alkaline. The content of coarse fragments is, by volume, less than 35 percent.

Vinland series

The Vinland series consists of shallow, somewhat excessively drained, moderately permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 4 to 30 percent.

Vinland soils are commonly adjacent to Knox, Martin, Morrill, and Sogn soils. The Knox, Martin, and Morrill soils are deeper than the Vinland soils. They have an argillic horizon. The Knox soils are on ridgetops and side slopes, the Martin soils are on foot slopes, and the Morrill soils are on the upper side slopes. The Sogn soils have limestone bedrock within 20 inches of the surface. They are on the upper side slopes.

Typical pedon of Vinland silty clay loam, in an area of Vinland-Sogn silty clay loams, 4 to 15 percent slopes, 2,500 feet west and 150 feet north of the southeast corner of sec. 22, T. 3 S., R. 19 E.

A1—0 to 8 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; hard, friable; slightly acid; gradual smooth boundary.

B2—8 to 12 inches; dark grayish brown (10YR 4/2) silty clay loam, grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; hard, friable; slightly acid; gradual smooth boundary.

C1—12 to 17 inches; olive brown (2.5Y 4/4) silty clay loam, light olive brown (2.5Y 5/4) dry; weak fine granular structure; hard, friable; slightly acid; clear wavy boundary.

Cr—17 inches; weathered silty shale.

The thickness of the solum and the depth to shale range from 10 to 20 inches. The mollic epipedon is 8 to 12 inches thick. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The B2 horizon has hue of 10YR, value of 3 to 5, and chroma of 2 to 4. The C horizon has hue of 7.5YR, 10YR, or 2.5Y, value of 4 to 6, and chroma of 2 to 4.

Classification of the soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (6). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. In table 16, the soils of the survey area are classified according to the system. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udoll (*Ud*, meaning humid, plus *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Hapludolls (*Hapl*, meaning minimal horizonation, plus *udoll*, the suborder of the Mollisols that have an udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Hapludolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-silty, mixed, mesic Typic Hapludolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Formation of the soils

This section relates the factors of soil formation to the soils in the county.

Soil forming processes act on deposited or accumulated geologic material. The characteristics of the soil at any given place are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, and (5) the length of time that the forces of soil formation have acted on the soil material. Each of these factors affects the formation of every soil, and each modifies the effects of the other four. The effects of each vary from place to place.

Parent material

Parent material is the unconsolidated material in which soil forms. It forms through chemical weathering and through the physical weathering of rocks caused by freezing, thawing, and blowing and by the grinding action of rivers and glaciers. In part of this county, glacial action increased the weathering process by scouring and grinding the rock. The action of the wind has also greatly influenced the type of parent material in which the soils formed.

Parent material influences the kind of soil that forms and the rate of formation. Many chemical and physical

properties of the soil are inherited from the parent material.

The parent materials in Doniphan County are residuum of limestone and shale, glacial sediments, loess deposits, and alluvial sediments.

Three different soils in the county formed in material weathered from interbedded limestone and shale of the Shawnee group of the Upper Pennsylvanian period (4). The very shallow and shallow Sogn soils formed in material weathered from limestone. The shallow Vinland soils and the deep Martin soils formed in material weathered from shale. The bedrock crops out on the bluffs along the Missouri River.

The Morrill soils are the only soils in the county that formed in Kansan glacial till. The till is mantled with loess and is exposed only along the lower parts of drainageways. It contains various amounts of gravel- and sand-size granite and quartz and various other rocks. Stones as much as 10 feet in diameter occur in some areas. In places the till contains local limestone and shale.

Most of the soils in this county formed in loess. The loess is more than 100 feet thick near White Cloud and thins out and is more clayey as distance from the Missouri River increases. The Knox, Marshall, and Monona soils formed in silty loess. The Monona soils are the most extensive of the soils that formed in loess (fig. 13).

Alluvium is the sediment deposited on flood plains by rivers and their tributaries. It ranges from sandy to clayey. The coarser sediments are near the stream, and the finer sediments are further away, in the lower depressional areas. The Sarpy soils formed in sandy alluvium, and the Haynie soils formed in loamy alluvium. The Albaton soils formed in clayey alluvium in depressional areas. All three soils are mainly along the Missouri River. The Colo and Kennebec soils formed in silty alluvium along the tributaries of the Missouri River. The Judson and Reading soils formed in silty alluvium on stream terraces.

Climate

Climate influences both the physical and chemical processes of weathering and the biological forces that work on the soil material. If the supply of moisture is adequate, the soil-forming processes become more active as the soil temperature increases. These processes are limited by inadequate or excess moisture.

The soils of Doniphan County formed under a moist, humid to subhumid climate. Summers are hot, and winters are moderately cold. The average annual precipitation is about 35 inches.

Temperature affects the decomposition of organic matter, the growth of organisms, and the rate of chemical reaction in the soils. The moderate amount of precipitation in the county has favored the growth of tall grasses. The downward movement of water is one of the main factors affecting the transformation of loess into a

soil that has distinct horizons. As water moves downward through the soil, calcium carbonate and salts are leached from the upper part of the soil and either form a lower horizon of enrichment or are carried out of the profile. The translocation of clay is partly caused by the downward movement of water.

Plant and animal life

Plants and animals furnish organic matter to the soil and transport soil and plant material from one layer to another. Organic matter creates a favorable environment for biological activity within the soil by providing food for micro-organisms. These organisms affect the chemical, physical, and biological processes of soil formation.

Most of the soils in Doniphan County formed under tall prairie grasses. These grasses added much organic matter to the soil, darkened the upper layers, and strengthened the soil structure.

Relief

Relief influences soil formation through its effect on runoff, drainage, erosion, soil temperature, and plant cover. The amount of water that enters the soil depends partly on topography. On the steeper soils, the loss of water through runoff and the continual removal of surface soil slow down the rate of soil formation. An example is the moderately steep and steep Hamburg soils. The rate of soil formation is more rapid in the gently sloping and moderately sloping Marshall soils, which are dark to a greater depth. It is most rapid in the nearly level and gently sloping soils, such as the Grundy soils.

Time

The length of time that is needed for a soil to form depends mainly on the other factors of soil formation. Soils form slowly if the climate is dry and the vegetation is sparse and much more rapidly if the climate is moist and the vegetation is dense.

Some soils in Doniphan County do not have distinct horizons because they have not been subject to the processes of soil formation for a long enough period. The moderately steep and steep Hamburg soils constantly lose soil material. As a result, they show minimal evidence of soil formation. The Haynie soils have weakly expressed horizons because they formed in recently deposited alluvial sediments. The nearly level and gently sloping Grundy soils have been in place long enough for well defined, genetically related horizons to form.

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Figure 13.—The parent material of Monona soils. These soils formed in Peoria loess about 20 feet thick over browner Loveland loess. Shale underlies the loess.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low.....	0 to 3
Low.....	3 to 6
Moderate.....	6 to 9
High.....	9 to 12
Very high.....	more than 12

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Catsteps. Local, very small, irregular terraces on steep hillsides, especially in pasture, formed by the trampling of cattle or the slippage of saturated soil.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Deferred grazing. Postponing grazing or arresting grazing for a prescribed period.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Drainage class (natural). Refers to the removal of water from the soil. Drainage classes are determined on the basis of an overall evaluation of water removal as influenced by climate, slope, and position on the landscape. Precipitation, runoff, amount of moisture infiltrating the soil, and rate of water movement through the soil affect the degree and duration of wetness. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. The soils in this class generally are free of mottles throughout. They commonly are shallow, very porous, or steep, or a combination of these.

Somewhat excessively drained.—Water is removed from the soil rapidly. The soils in this class generally are free of mottles throughout. They commonly are shallow or moderately deep, very porous, or steep, or a combination of these.

Well drained.—Water is removed from the soil so readily that the upper 40 inches generally does not have the mottles or dull colors related to wetness.

Moderately well drained.—Water is removed from the soil so slowly that the upper 20 to 40 inches has the mottles and dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Somewhat poorly drained.—Water is removed from the soil so slowly that the upper 10 to 20 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Poorly drained.—Water is removed so slowly that either the soil is periodically saturated or the upper 10 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water is at or on the surface most of the time. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Drainage, surface. Runoff, or surface flow of water, from an area.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Excess fines (in tables). Excess silt and clay in the soil. The soil does not provide a source of gravel or sand for construction purposes.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue at the surface of a mineral soil.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves through the saturated soil. Terms describing permeability are:

Very slow.....	less than 0.06 inch
Slow.....	0.06 to 0.20 inch
Moderately slow.....	0.2 to 0.6 inch
Moderate.....	0.6 inch to 2.0 inches
Moderately rapid.....	2.0 to 6.0 inches
Rapid.....	6.0 to 20 inches
Very rapid.....	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid.....	below 4.5
Very strongly acid.....	4.5 to 5.0
Strongly acid.....	5.1 to 5.5
Medium acid.....	5.6 to 6.0
Slightly acid.....	6.1 to 6.5
Neutral.....	6.6 to 7.3
Mildly alkaline.....	7.4 to 7.8
Moderately alkaline.....	7.9 to 8.4
Strongly alkaline.....	8.5 to 9.0
Very strongly alkaline.....	9.1 and higher

Rippable. Bedrock or hardpan can be excavated using a single-tooth ripping attachment mounted on a tractor with a 200-300 draw bar horsepower rating.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in di-

ameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slow Intake (in tables). The slow movement of water into the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A1, A2, or A3) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A horizon. Includes all subdivisions of this horizon (A1, A2, and A3).

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that the water can soak into the soil or flow slowly to a prepared outlet. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine

particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress road-banks, lawns, and land affected by mining.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

TABLES

TABLE 1.--TEMPERATURE AND PRECIPITATION

Month	Temperature					Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have--		Average	2 years in 10 will have--		Average number of days with 0.10 inch or more	Average snowfall
				Maximum temperature higher than--	Minimum temperature lower than--		Less than--	More than--		
	<u>°F</u>	<u>°F</u>	<u>°F</u>	<u>°F</u>	<u>°F</u>	<u>In</u>	<u>In</u>	<u>In</u>		<u>In</u>
January----	35.8	16.3	26.1	66	-14	0.98	0.26	1.64	2	6.1
February---	42.3	21.6	32.0	71	- 7	1.03	0.22	1.54	2	3.3
March-----	51.1	28.8	40.0	82	2	2.09	0.54	3.60	4	4.2
April-----	66.0	42.4	54.2	90	20	2.97	1.48	4.24	6	0.7
May-----	76.0	53.7	64.9	92	34	4.82	2.62	7.12	6	0.0
June-----	83.8	62.4	73.1	97	45	5.80	2.79	9.00	8	0.0
July-----	88.5	66.8	77.6	102	53	4.19	1.99	6.66	6	0.0
August-----	86.8	64.5	75.7	100	48	3.99	1.55	6.17	5	0.0
September--	79.5	56.1	67.8	97	38	4.39	2.24	6.67	6	0.0
October----	69.8	46.1	58.0	90	24	2.58	0.86	4.89	4	0.0
November---	53.2	31.9	42.6	76	5	1.20	0.15	2.15	2	0.7
December---	40.2	21.8	31.0	65	- 8	0.99	0.40	1.62	3	5.1
Year-----	64.4	42.7	53.6	102	-14	35.03	26.89	43.92	54	20.1

TABLE 2.--FREEZE DATES IN SPRING AND FALL

Probability	Minimum temperature		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	April 14	April 23	May 4
2 years in 10 later than--	April 10	April 18	April 29
5 years in 10 later than--	April 1	April 8	April 19
First freezing temperature in fall:			
1 year in 10 earlier than--	October 21	October 14	October 3
2 years in 10 earlier than--	October 26	October 19	October 7
5 years in 10 earlier than--	November 5	October 28	October 17

TABLE 3.--GROWING SEASON

Probability	Daily minimum temperature during growing season		
	Higher than 24° F Days	Higher than 28° F Days	Higher than 32° F Days
9 years in 10	196	181	153
8 years in 10	203	189	166
5 years in 10	218	203	181
2 years in 10	231	216	194
1 year in 10	237	224	202

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
Ab	Albaton silty clay-----	2,800	1.1
At	Aquents-----	720	0.3
Co	Colo silt loam-----	4,300	1.7
Gb	Grundy silty clay loam, 0 to 2 percent slopes-----	1,200	0.5
Gc	Grundy silty clay loam, 2 to 6 percent slopes-----	900	0.4
Ha	Hamburg silt loam, 25 to 50 percent slopes-----	10,200	4.1
Hn	Haynie silt loam-----	4,800	1.9
Ho	Haynie-Onawa complex-----	3,200	1.3
Hs	Haynie-Sarpy complex-----	1,500	0.6
Ju	Judson silt loam, 1 to 3 percent slopes-----	2,500	1.0
Ke	Kennebec silt loam-----	11,300	4.4
Kf	Kennebec silt loam, channeled-----	2,800	1.1
Kn	Knox silt loam, 4 to 10 percent slopes, eroded-----	2,600	1.0
Ko	Knox silt loam, 10 to 18 percent slopes, eroded-----	14,300	5.6
Kp	Knox silt loam, 18 to 30 percent slopes, eroded-----	9,200	3.6
Ma	Marshall silt loam, 1 to 3 percent slopes-----	6,800	2.7
Mb	Marshall silt loam, 3 to 7 percent slopes-----	18,400	7.2
Mc	Martin silty clay loam, 3 to 7 percent slopes, eroded-----	710	0.3
Md	Monona silt loam, 3 to 10 percent slopes-----	25,300	10.0
Me	Monona silt loam, 3 to 10 percent slopes, eroded-----	11,000	4.3
Mf	Monona silt loam, 10 to 18 percent slopes, eroded-----	49,000	19.2
Mh	Monona-Hamburg silt loams, 18 to 30 percent slopes, eroded-----	30,000	11.8
Mo	Morrill loam, 2 to 7 percent slopes, eroded-----	3,400	1.3
Mp	Morrill loam, 7 to 12 percent slopes, eroded-----	7,000	2.7
Ms	Morrill loam, 12 to 18 percent slopes, eroded-----	3,300	1.3
Od	Onawa loam-----	5,200	2.0
On	Onawa silty clay loam-----	7,000	2.7
Pt	Pits, quarries-----	526	0.2
Re	Reading silt loam-----	820	0.3
Sa	Sarpy loamy fine sand-----	1,200	0.5
Vr	Vinland-Rock outcrop complex, 20 to 40 percent slopes-----	4,200	1.6
Vs	Vinland-Sogn silty clay loams, 4 to 15 percent slopes-----	2,400	0.9
	Water-----	6,144	2.4
	Total-----	254,720	100.0

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Grain sorghum	Soybeans	Winter wheat	Smooth brome grass
	Bu	Bu	Bu	Bu	AUM*
Ab----- Albaton	70	65	28	28	4.0
At**. Aquents					
Co----- Colo	95	95	42	42	6.0
Gb----- Grundy	85	85	36	38	6.5
Gc----- Grundy	80	80	34	36	6.0
Ha----- Hamburg	---	---	---	---	3.0
Hn***. Haynie	95	90	36	38	6.5
Ho----- Haynie-Onawa	85	85	34	36	6.0
Hs----- Haynie-Sarpy	65	65	26	30	4.0
Ju----- Judson	110	110	44	46	7.0
Ke----- Kennebec	100	100	40	44	7.0
Kf. Kennebec					
Kn----- Knox	85	80	32	34	6.0
Ko----- Knox	75	70	28	30	5.0
Kp----- Knox	---	---	---	---	4.0
Ma----- Marshall	95	95	38	40	6.5
Mb----- Marshall	90	90	36	38	6.0
Mc----- Martin	70	70	28	32	5.0
Md----- Monona	100	95	36	38	6.5
Me----- Monona	95	85	34	36	6.0
Mf----- Monona	80	75	30	32	5.0

See footnotes at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Grain sorghum	Soybeans	Winter wheat	Smooth brome grass
	<u>Bu</u>	<u>Bu</u>	<u>Bu</u>	<u>Bu</u>	<u>AUM*</u>
Mh----- Monona-Hamburg	---	---	---	---	4.0
Mo----- Morrill	75	75	32	34	6.0
Mp----- Morrill	65	65	28	30	5.5
Ms----- Morrill	---	---	---	---	5.0
Od----- Onawa	80	80	30	30	---
On----- Onawa	85	80	32	34	5.5
Pt**. Pits					
Re----- Reading	95	100	44	46	7.0
Sa----- Sarpy	---	---	---	15	2.0
Vr. Vinland-Rock outcrop					
Vs. Vinland-Sogn					

* Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

** See description of the map unit for composition and behavior characteristics of the map unit.

*** Yields are for areas protected from flooding.

TABLE 6.--WOODLAND MANAGEMENT AND PRODUCTIVITY

[Only the soils suitable for production of commercial trees are listed. Absence of an entry indicates that information was not available]

Soil name and map symbol	Management concerns					Potential productivity		Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Wind-throw hazard	Plant competition	Common trees	Site index	
Ha----- Hamburg	Severe	Severe	Severe	Slight	Slight	White oak----- Bur oak----- Eastern redcedar----	45 --- ---	Yellow-poplar, eastern redcedar.
Hn----- Haynie	Slight	Slight	Slight	Slight	Moderate	Eastern cottonwood-- American sycamore--- Black walnut----- Green ash-----	110 110 --- ---	Black walnut, eastern cottonwood.
Ho*: Haynie-----	Slight	Slight	Slight	Slight	Moderate	Eastern cottonwood-- American sycamore--- Black walnut----- Green ash-----	110 110 --- ---	Black walnut, eastern cottonwood.
Onawa.								
Hs*: Haynie-----	Slight	Slight	Slight	Slight	Moderate	Eastern cottonwood-- American sycamore--- Black walnut----- Green ash-----	110 110 --- ---	Black walnut, eastern cottonwood.
Sarpy-----	Slight	Slight	Severe	Slight	Slight	Eastern cottonwood-- Silver maple-----	95 90	Eastern cottonwood, black willow, American sycamore.
Ju----- Judson	Slight	Slight	Slight	Slight	Moderate	Black walnut----- White oak----- Northern red oak----	73 --- ---	Black walnut, eastern cottonwood, green ash.
Ke, Kf----- Kennebec	Slight	Slight	Slight	Slight	Moderate	Black walnut----- Bur oak----- Common hackberry--- Green ash----- Eastern cottonwood--	79 63 --- --- ---	Black walnut, bur oak, common hackberry, green ash, eastern cottonwood, American sycamore.
Kn, Ko----- Knox	Slight	Slight	Slight	Slight	Slight	White oak-----	65	Shortleaf pine, green ash, black walnut, yellow-poplar.
Kp----- Knox	Moderate	Moderate	Moderate	Slight	Slight	White oak-----	65	Shortleaf pine, green ash, black walnut, yellow-poplar.
Mc----- Martin	Slight	Slight	Slight	Slight	Slight	Black walnut----- White oak-----	68 60	Black walnut, white oak, black oak, common hackberry, green ash, shagbark hickory.
Mh*: Monona.								
Hamburg-----	Moderate	Moderate	Moderate	Slight	Slight	White oak----- Bur oak----- Eastern redcedar----	45 --- ---	Yellow-poplar.

See footnote at end of table.

TABLE 6.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Management concerns					Potential productivity		Trees to plant
	Erosion hazard	Equip- ment limita- tion	Seedling mortal- ity	Wind- throw hazard	Plant competi- tion	Common trees	Site index	
Re----- Reading	Slight	Slight	Slight	Slight	Moderate	Black walnut----- Common hackberry---- Bur oak----- Shagbark hickory---- Southern red oak----	73 69 60 62 ---	Black walnut, green ash, common hackberry, American sycamore, eastern cottonwood.
Sa----- Sarpy	Slight	Slight	Severe	Slight	Slight	Eastern cottonwood-- Silver maple-----	95 90	Eastern cottonwood, black willow, American sycamore.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Ab----- Albaton	Severe: floods, wetness, percs slowly.	Severe: too clayey.	Severe: too clayey, wetness, percs slowly.	Severe: too clayey.
At#. Aquentz				
Co----- Colo	Severe: floods, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.
Gb, Gc----- Grundy	Severe: wetness.	Moderate: wetness, too clayey.	Severe: wetness.	Moderate: wetness, too clayey.
Ha----- Hamburg	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Hn----- Haynie	Severe: floods.	Slight-----	Moderate: floods.	Slight.
Ho#: Haynie-----	Severe: floods.	Slight-----	Moderate: floods.	Slight.
.Onawa-----	Severe: floods.	Moderate: wetness.	Moderate: floods.	Slight.
Hs#: Haynie-----	Severe: floods.	Slight-----	Moderate: floods.	Slight.
Sarpy-----	Severe: floods.	Moderate: too sandy.	Moderate: floods.	Moderate: too sandy.
Ju----- Judson	Slight-----	Slight-----	Slight-----	Slight.
Ke----- Kennebec	Severe: floods.	Slight-----	Moderate: floods.	Slight.
Kf----- Kennebec	Severe: floods.	Moderate: floods.	Severe: floods.	Moderate: floods.
Kn----- Knox	Slight-----	Slight-----	Severe: slope.	Slight.
Ko----- Knox	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight.
Kp----- Knox	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Ma----- Marshall	Slight-----	Slight-----	Moderate: slope.	Slight.
Mb----- Marshall	Slight-----	Slight-----	Moderate: slope.	Slight.

See footnote at end of table.

TABLE 7.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Mc----- Martin	Moderate: too clayey, percs slowly.	Moderate: percs slowly.	Moderate: percs slowly, slope.	Slight.
Md, Me----- Monona	Slight-----	Slight-----	Severe: slope.	Slight.
Mf----- Monona	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight.
Mh*: Monona-----	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Hamburg-----	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Mo----- Morrill	Moderate: percs slowly.	Slight-----	Moderate: slope, percs slowly.	Slight.
Mp----- Morrill	Moderate: slope, percs slowly.	Moderate: slope.	Severe: slope.	Slight.
Ms----- Morrill	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
Od, On----- Onawa	Severe: floods.	Moderate: wetness.	Moderate: floods.	Slight.
Pt*. Pits				
Re----- Reading	Moderate: percs slowly.	Slight-----	Moderate: percs slowly.	Slight.
Sa----- Sarpy	Severe: floods.	Moderate: too sandy.	Moderate: floods.	Moderate: too sandy.
Vr*: Vinland-----	Severe: slope.	Severe: slope.	Severe: depth to rock, slope.	Severe: slope.
Rock outcrop.				
Vs*: Vinland-----	Moderate: slope.	Moderate: slope.	Severe: depth to rock, slope.	Slight.
Sogn-----	Severe: depth to rock.	Moderate: slope.	Severe: depth to rock, slope.	Slight.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--WILDLIFE HABITAT POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements								Potential as habitat for--			
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hard- wood trees	Conif- erous plants	Shrubs	Wetland plants	Shallow water areas	Open- land wild- life	Wood- land wild- life	Wetland wild- life	Range- land wild- life
Ab----- Albaton	Fair	Fair	Fair	Poor	Very poor.	---	Good	Good	Fair	Poor	Good	---
At*. Aquents												
Co----- Colo	Good	Fair	Good	Fair	Poor	---	Good	Good	Fair	Fair	Good	---
Gb, Gc----- Grundy	Fair	Good	Fair	Good	Good	---	Fair	Fair	Fair	Good	Fair	---
Ha----- Hamburg	Very poor.	Poor	Fair	Fair	Fair	---	Very poor.	Very poor.	Poor	Fair	Very poor.	---
Hn----- Haynie	Good	Good	Good	Good	Good	---	Poor	Poor	Good	Good	Poor	---
Ho*: Haynie-----	Good	Good	Good	Good	Good	---	Poor	Poor	Good	Good	Poor	---
Onawa-----	Fair	Fair	Fair	Poor	Very poor.	---	Good	Good	Fair	Poor	Good	---
Hs*: Haynie-----	Good	Good	Good	Good	Good	---	Poor	Poor	Good	Good	Poor	---
Sarpy-----	Poor	Poor	Fair	Poor	Poor	---	Very poor.	Very poor.	Poor	Poor	Very poor.	---
Ju----- Judson	Good	Good	Good	Good	Good	---	Poor	Poor	Good	Good	Poor	---
Ke, Kf----- Kennebec	Good	Good	Good	Good	Good	---	Poor	Poor	Good	Good	Poor	---
Kn, Ko----- Knox	Fair	Good	Good	Good	Good	---	Very poor.	Very poor.	Good	Good	Very poor.	---
Kp----- Knox	Poor	Fair	Good	Good	Good	---	Very poor.	Very poor.	Fair	Good	Very poor.	---
Ma, Mb----- Marshall	Good	Good	Good	Fair	Fair	---	Poor	Poor	Good	Fair	Poor	---
Mc----- Martin	Fair	Good	Good	Good	Good	Good	Poor	Very poor.	Good	---	Very poor.	Good.
Md, Me----- Monona	Good	Good	Good	Good	Good	---	Very poor.	Very poor.	Good	Good	Very poor.	---
Mf----- Monona	Fair	Good	Good	Good	Good	---	Very poor.	Very poor.	Good	Good	Very poor.	---
Mh*: Monona-----	Poor	Fair	Good	Fair	Fair	---	Very poor.	Very poor.	Fair	Fair	Very poor.	---
Hamburg-----	Poor	Fair	Fair	Fair	Fair	---	Very poor.	Very poor.	Fair	Fair	Very poor.	---
Mo, Mp----- Morrill	Fair	Good	Good	Good	Good	Good	Poor	Very poor.	Good	---	Very poor.	Good.

See footnote at end of table.

TABLE 8.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements								Potential as habitat for--			
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hard- wood trees	Conif- erous plants	Shrubs	Wetland plants	Shallow water areas	Open- land wild- life	Wood- land wild- life	Wetland wild- life	Range- land wild- life
Ms----- Morrill	Poor	Fair	Good	Good	Good	Good	Poor	Very poor.	Fair	---	Very poor.	Good.
Od, On----- Onawa	Fair	Fair	Fair	Poor	Very poor.	---	Good	Good	Fair	Poor	Good	---
Pt*. Pits												
Re----- Reading	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor	---
Sa----- Sarpy	Poor	Poor	Fair	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.	---
Vr*: Vinland-----	Poor	Poor	Fair	Fair	Fair	---	Very poor.	Very poor.	Poor	Fair	Very poor.	---
Rock outcrop.												
Vs*: Vinland-----	Poor	Poor	Fair	Fair	Fair	---	Very poor.	Very poor.	Poor	Fair	Very poor.	---
Sogn-----	Very poor.	Very poor.	Poor	---	---	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Poor.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Ab----- Albaton	Severe: wetness, floods.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: wetness, low strength, floods.
At*. Aquents					
Co----- Colo	Severe: wetness, floods.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, low strength, shrink-swell.
Gb, Gc----- Grundy	Severe: wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: low strength, frost action, shrink-swell.
Ha----- Hamburg	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, frost action.
Hn----- Haynie	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: frost action, floods.
Ho*: Haynie-----	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods, frost action.
Onawa-----	Severe: wetness, floods.	Severe: floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: wetness, low strength, shrink-swell.
Hs*: Haynie-----	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods, frost action.
Sarpy-----	Severe: cutbanks cave, floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
Ju----- Judson	Slight-----	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.
Ke, Kf----- Kennebec	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods, frost action, low strength.
Kn----- Knox	Slight-----	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: frost action, low strength.
Ko----- Knox	Moderate: slope.	Moderate: slope, shrink-swell.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: frost action, low strength.
Kp----- Knox	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: frost action, slope, low strength.

See footnote at end of table.

TABLE 9.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Ma----- Marshall	Slight-----	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.
Mb----- Marshall	Slight-----	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.
Mc----- Martin	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell, frost action.
Md, Me----- Monona	Slight-----	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: low strength, frost action.
Mf----- Monona	Moderate: slope.	Moderate: slope, shrink-swell.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength, frost action.
Mh*: Monona-----	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope, frost action.
Hamburg-----	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, frost action.
Mo----- Morrill	Slight-----	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: low strength.
Mp----- Morrill	Moderate: slope.	Moderate: slope, shrink-swell.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.
Ms----- Morrill	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, low strength.
Od, On----- Onawa	Severe: wetness, floods.	Severe: floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: low strength, shrink-swell, floods.
Pt*. Pits					
Re----- Reading	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, frost action.
Sa----- Sarpy	Severe: cutbanks cave, floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.
Vr*: Vinland-----	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, low strength.
Rock outcrop.					

See footnote at end of table.

TABLE 9.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Vs*: Vinland-----	Severe: depth to rock.	Moderate: depth to rock, slope, shrink-swell.	Severe: depth to rock.	Severe: slope.	Severe: low strength.
Sogn-----	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Ab----- Albaton	Severe: percs slowly, wetness, floods.	Severe: floods.	Severe: wetness, too clayey, floods.	Severe: wetness, floods.	Poor: wetness, too clayey.
At*. Aquentz					
Co----- Colo	Severe: percs slowly, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
Gb----- Grundy	Severe: percs slowly, wetness.	Slight-----	Severe: too clayey, wetness.	Severe: wetness.	Poor: too clayey, wetness.
Gc----- Grundy	Severe: percs slowly, wetness.	Moderate: slope.	Severe: too clayey, wetness.	Severe: wetness.	Poor: too clayey, wetness.
Ha----- Hamburg	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Hn----- Haynie	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
Ho*: Haynie-----	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
Onawa-----	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Good.
Hs*: Haynie-----	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Good.
Sarpy-----	Severe: floods.	Severe: seepage, floods.	Severe: seepage, floods, too sandy.	Severe: seepage, floods.	Poor: too sandy, seepage.
Ju----- Judson	Slight-----	Moderate: seepage.	Slight-----	Slight-----	Good.
Ke, Kf----- Kennebec	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Good.
Kn----- Knox	Slight-----	Moderate: slope.	Slight-----	Slight-----	Fair: too clayey.
Ko----- Knox	Moderate: slope.	Severe: slope.	Slight-----	Moderate: slope.	Fair: slope, too clayey.
Kp----- Knox	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.	Poor: slope.

See footnote at end of table.

TABLE 10.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Ma, Mb----- Marshall	Slight-----	Moderate: seepage, slope.	Slight-----	Slight-----	Fair: too clayey.
Mc----- Martin	Severe: percs slowly.	Moderate: slope.	Severe: too clayey, depth to rock.	Slight-----	Poor: too clayey.
Md, Me----- Monona	Slight-----	Moderate: seepage, slope.	Slight-----	Slight-----	Good.
Mf----- Monona	Moderate: slope.	Severe: slope.	Slight-----	Moderate: slope.	Fair: slope.
Mh*: Monona-----	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.	Poor: slope.
Hamburg-----	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.	Poor: slope.
Mo----- Morrill	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight-----	Fair: too clayey.
Mp----- Morrill	Severe: percs slowly.	Severe: slope.	Moderate: too clayey.	Moderate: slope.	Fair: too clayey, slope.
Ms----- Morrill	Severe: percs slowly, slope.	Severe: slope.	Moderate: too clayey, slope.	Severe: slope.	Poor: slope.
Od, On----- Onawa	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Fair: wetness.
Pt*. Pits					
Re----- Reading	Severe: percs slowly, wetness.	Moderate: seepage, wetness.	Moderate: too clayey, wetness, floods.	Moderate: floods.	Fair: too clayey.
Sa----- Sarpy	Severe: floods.	Severe: seepage, floods.	Severe: seepage, floods, too sandy.	Severe: seepage, floods.	Poor: too sandy, seepage.
Vr*: Vinland-----	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Poor: slope, area reclaim.
Rock outcrop.					
Vs*: Vinland-----	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Moderate: slope, depth to rock.	Poor: area reclaim.
Sogn-----	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and "poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Ab----- Albaton	Poor: wetness, low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: too clayey.
At*. Aquents				
Co----- Colo	Poor: wetness, shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Gb, Gc----- Grundy	Poor: low strength, shrink-swell, wetness.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey, thin layer.
Ha----- Hamburg	Poor: slope.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
Hn----- Haynie	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Ho*: Haynie-----	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Onawa-----	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
Hs*: Haynie-----	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Sarpy-----	Good-----	Poor: excess fines.	Unsuited: excess fines.	Fair: too sandy.
Ju----- Judson	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Ke, Kf----- Kennebec	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Kn----- Knox	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Ko----- Knox	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer, slope.
Kp----- Knox	Poor: low strength, slope.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
Ma, Mb----- Marshall	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Mo----- Martin	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
Md, Me----- Monona	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.

See footnote at end of table.

TABLE 11.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Mf----- Monona	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: slope.
Mh*: Monona-----	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
Hamburg-----	Fair: slope, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
Mo----- Morrill	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Mp----- Morrill	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer, slope.
Ms----- Morrill	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
Od, On----- Onawa	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: too clayey.
Pt*. Pits				
Re----- Reading	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Sa----- Sarpy	Good-----	Poor: excess fines.	Unsuited: excess fines.	Fair: too sandy.
Vr*: Vinland-----	Poor: thin layer, slope, area reclaim.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
Rock outcrop.				
Vs*: Vinland-----	Poor: thin layer, area reclaim, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey, slope, area reclaim.
Sogn-----	Poor: thin layer, area reclaim, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: area reclaim.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Ab----- Albaton	Favorable-----	Hard to pack, wetness.	Peres slowly, floods.	Wetness, slow intake, peres slowly, floods.	Not needed-----	Peres slowly, wetness.
At*. Aquets						
Co----- Colo	Favorable-----	Hard to pack, wetness.	Floods, frost action.	Floods, wetness.	Not needed-----	Wetness, erodes easily.
Gb----- Grundy	Favorable-----	Hard to pack, wetness.	Peres slowly, frost action.	Peres slowly, wetness.	Not needed-----	Wetness, erodes easily, peres slowly.
Gc----- Grundy	Favorable-----	Hard to pack, wetness.	Peres slowly, frost action.	Peres slowly, wetness.	Wetness, peres slowly.	Wetness, erodes easily, peres slowly.
Ha----- Hamburg	Slope, seepage.	Piping-----	Not needed-----	Slope, erodes easily.	Slope, erodes easily.	Erodes easily, slope.
Hn----- Haynie	Seepage-----	Favorable-----	Not needed-----	Floods-----	Not needed-----	Erodes easily.
Ho*: Haynie-----	Seepage-----	Favorable-----	Not needed-----	Floods-----	Not needed-----	Erodes easily.
Onawa-----	Seepage-----	Wetness-----	Peres slowly, floods, frost action.	Peres slowly, wetness, floods.	Not needed-----	Peres slowly.
Hs*: Haynie-----	Seepage-----	Favorable-----	Not needed-----	Floods-----	Not needed-----	Erodes easily.
Sarpy-----	Seepage-----	Piping, seepage.	Not needed-----	Droughty, fast intake, soil blowing.	Not needed-----	Droughty.
Ju----- Judson	Seepage-----	Favorable-----	Not needed-----	Favorable-----	Favorable-----	Erodes easily.
Ke, Kf----- Kennebec	Seepage-----	Favorable-----	Floods, frost action.	Floods-----	Not needed-----	Erodes easily.
Kn----- Knox	Seepage, slope.	Favorable-----	Not needed-----	Slope-----	Erodes easily	Erodes easily.
Ko, Kp----- Knox	Seepage, slope.	Favorable-----	Not needed-----	Slope-----	Slope, erodes easily.	Slope, erodes easily.
Ma----- Marshall	Seepage-----	Favorable-----	Not needed-----	Favorable-----	Erodes easily	Erodes easily.
Mb----- Marshall	Seepage-----	Favorable-----	Not needed-----	Favorable-----	Erodes easily	Erodes easily.
Mc----- Martin	Favorable-----	Hard to pack---	Not needed-----	Peres slowly, erodes easily.	Peres slowly---	Erodes easily, peres slowly.
Md, Me----- Monona	Seepage, slope.	Favorable-----	Not needed-----	Slope-----	Erodes easily	Erodes easily.
Mf----- Monona	Seepage, slope.	Favorable-----	Not needed-----	Slope-----	Slope, erodes easily.	Slope, erodes easily.

See footnote at end of table.

TABLE 12.--WATER MANAGEMENT--Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Mh*: Monona-----	Seepage, slope.	Favorable-----	Not needed-----	Slope-----	Slope, erodes easily.	Slope, erodes easily.
Hamburg-----	Slope, seepage.	Piping-----	Not needed-----	Slope, erodes easily.	Slope, erodes easily.	Erodes easily, slope.
Mo----- Morrill	Favorable-----	Favorable-----	Not needed-----	Favorable-----	Favorable-----	Favorable.
Mp----- Morrill	Slope-----	Favorable-----	Not needed-----	Slope-----	Favorable-----	Slope.
Ms----- Morrill	Slope-----	Favorable-----	Not needed-----	Slope-----	Slope-----	Slope.
Od, On----- Onawa	Seepage-----	Wetness-----	Peres slowly, floods, frost action.	Peres slowly, wetness, floods.	Not needed-----	Erodes easily, peres slowly.
Pt*. Pits						
Re----- Reading	Favorable-----	Favorable-----	Not needed-----	Favorable-----	Not needed-----	Erodes easily.
Sa----- Sarpy	Seepage-----	Piping, seepage.	Not needed-----	Droughty, fast intake, soil blowing.	Not needed-----	Droughty.
Vr*: Vinland-----	Slope, depth to rock.	Thin layer-----	Not needed-----	Rooting depth, slope, droughty.	Slope, depth to rock.	Slope, rooting depth, droughty.
Rock outcrop.						
Vs*: Vinland-----	Slope, depth to rock.	Thin layer-----	Not needed-----	Rooting depth, slope, droughty.	Depth to rock	Slope, rooting depth, droughty.
Sogn-----	Slope, depth to rock.	Thin layer-----	Not needed-----	Droughty, rooting depth, slope.	Depth to rock	Slope, droughty, rooting depth.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--ENGINEERING PROPERTIES AND CLASSIFICATIONS

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct.	
Ab----- Albaton	0-8 8-60	Silty clay----- Silty clay, clay	CH CH	A-7 A-7	0 0	100 100	100 100	95-100 95-100	95-100 95-100	60-85 60-85	40-60 40-60
At*. Aquets											
Co----- Colo	0-10 10-60	Silt loam----- Silty clay loam	CL, CL-ML CL, CH	A-4, A-6 A-7	0 0	100 100	100 100	95-100 90-100	95-100 90-100	25-40 40-55	5-15 20-30
Gb, Gc----- Grundy	0-13 13-19 19-30 30-60	Silty clay loam Silty clay loam, silty clay. Silty clay, silty clay loam. Silty clay loam	CL CH, CL CH CH, CL	A-6, A-7 A-7, A-6 A-7 A-7, A-6	0 0 0 0	100 100 100 100	100 100 100 100	95-100 95-100 95-100 90-100	90-100 90-100 90-100 90-100	30-45 45-55 50-70 40-55	10-20 25-35 30-45 25-35
Ha----- Hamburg	0-11 11-60	Silt loam----- Silt loam, very fine sandy loam.	CL, ML, CL-ML CL, ML, CL-ML	A-4 A-4, A-6	0 0	100 100	100 100	100 100	95-100 95-100	20-30 20-35	5-10 5-15
Hn----- Haynie	0-8 8-60	Silt loam----- Silt loam, very fine sandy loam.	CL, CL-ML CL, CL-ML	A-4, A-6 A-4, A-6	0 0	100 100	100 100	90-100 90-100	70-100 70-100	25-40 25-40	5-15 5-15
Ho*: Haynie-----	0-8 8-60	Silt loam----- Silt loam, very fine sandy loam.	CL, CL-ML CL, CL-ML	A-4, A-6 A-4, A-6	0 0	100 100	100 100	90-100 90-100	70-100 70-100	25-40 25-40	5-15 5-15
Onawa-----	0-8 8-26 26-60	Silty clay loam Silty clay----- Silt loam, very fine sandy loam, loam.	CH CH CL, CL-ML	A-7 A-7 A-4, A-6	0 0 0	100 100 100	100 100 100	95-100 95-100 95-100	95-100 95-100 85-100	60-85 60-85 25-40	40-60 40-60 5-20
Hs*: Haynie-----	0-8 8-60	Very fine sandy loam. Silt loam, very fine sandy loam.	CL CL, CL-ML	A-4, A-6 A-4, A-6	0 0	100 100	100 100	90-100 90-100	70-100 70-100	25-40 25-40	5-15 5-15
Sarpy-----	0-5 5-64	Loamy fine sand Loamy fine sand, fine sand.	SM SM, SP, SP-SM	A-2 A-2	0 0	100 100	100 100	60-80 60-80	15-35 2-35	--- ---	NP NP
Ju----- Judson	0-13 13-60	Silt loam----- Silty clay loam, silt loam.	CL, CL-ML CL, CL-ML	A-6, A-7, A-4 A-6, A-7, A-4	0 0	100 100	100 100	100 100	95-100 95-100	25-50 25-50	5-25 5-25
Ke, Kf----- Kennebec	0-46 46-60	Silt loam----- Silt loam, silty clay loam.	CL CL, CL-ML	A-6, A-4 A-6, A-4	0 0	100 100	100 100	95-100 95-100	90-100 90-100	25-45 25-40	10-20 5-15
Kn, Ko, Kp----- Knox	0-8 8-53 53-60	Silt loam----- Silty clay loam, silt loam. Silt loam-----	CL-ML, CL CL CL-ML, CL	A-4 A-6 A-4, A-6	0 0 0	100 100 100	100 100 100	95-100 95-100 95-100	90-100 95-100 90-100	20-30 30-40 25-35	5-10 10-20 5-15

See footnote at end of table.

TABLE 13.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Ma, Mb----- Marshall	0-7 7-60	Silt loam----- Silty clay loam	CL CL	A-6, A-7 A-7, A-6	0 0	100 100	100 100	100 100	95-100 95-100	35-50 35-50	15-25 15-25
Mc----- Martin	0-7 7-51 51	Silty clay loam Silty clay, clay Unweathered bedrock.	CL CH, CL ---	A-6, A-7 A-7 ---	0 0 ---	100 100 ---	100 100 ---	95-100 95-100 ---	80-99 80-98 ---	35-50 41-70 ---	15-25 25-40 ---
Md, Me, Mf----- Monona	0-11 11-25 25-60	Silt loam----- Silt loam, silty clay loam. Silt loam-----	ML, CL ML, CL CL	A-6, A-7 A-6, A-7 A-6, A-7	0 0 0	100 100 100	100 100 100	95-100 95-100 95-100	95-100 95-100 95-100	35-50 35-50 30-45	10-25 10-25 10-20
Mh*: Monona-----	0-11 11-25 25-60	Silt loam----- Silt loam, silty clay loam. Silt loam-----	ML, CL ML, CL CL	A-6, A-7 A-6, A-7 A-6, A-7	0 0 0	100 100 100	100 100 100	95-100 95-100 95-100	95-100 95-100 95-100	35-50 35-50 30-45	10-25 10-25 10-20
Hamburg-----	0-11 11-60	Silt loam----- Silt loam, very fine sandy loam.	CL, ML, CL-ML CL, ML, CL-ML	A-4 A-4, A-6	0 0	100 100	100 100	100 100	95-100 95-100	20-30 20-35	5-10 5-15
Mo, Mp, Ms----- Morrill	0-5 5-54 54-60	Loam----- Clay loam, sandy clay loam. Loam, clay loam, sandy loam.	ML, CL, CL-ML CL CL, ML	A-4, A-6 A-4, A-6, A-7 A-4, A-6	0 0 0	100 100 100	100 100 100	94-100 90-100 90-100	50-85 55-85 55-85	20-35 30-45 25-40	2-15 8-20 2-15
Od----- Onawa	0-16 16-38 38-60	Loam----- Silty clay----- Silt loam, very fine sandy loam, loam.	CL, CL-ML CH CL, CL-ML	A-4, A-6 A-7 A-4, A-6	0 0 0	100 100 100	100 100 100	95-100 95-100 95-100	90-100 95-100 85-100	25-40 60-85 25-40	5-20 40-60 5-20
On----- Onawa	0-8 8-26 26-60	Silty clay loam Silty clay----- Silt loam, very fine sandy loam, loam.	CH CH CL, CL-ML	A-7 A-7 A-4, A-6	0 0 0	100 100 100	100 100 100	95-100 95-100 95-100	95-100 95-100 85-100	60-85 60-85 25-40	40-60 40-60 5-20
Pt*. Pits											
Re----- Reading	0-14 14-46 46-60	Silt loam----- Silty clay loam Silty clay loam, clay loam, silty clay.	CL, CL-ML CL CL	A-4, A-6 A-6, A-7 A-6, A-7	0 0 0	100 100 100	100 100 100	90-100 95-100 95-100	85-100 90-100 80-100	25-40 35-50 35-50	5-20 15-30 15-30
Sa----- Sarpy	0-5 5-60	Loamy fine sand Loamy fine sand, fine sand.	SM SM, SP SP-SM	A-2 A-2	0 0	100 100	100 100	60-80 60-80	15-35 2-35	--- ---	NP NP
Vr*: Vinland-----	0-17 17	Silty clay loam Weathered bedrock.	ML, CL ---	A-6, A-7 ---	0 ---	85-100 ---	85-100 ---	80-100 ---	75-95 ---	35-50 ---	10-25 ---
Rock outcrop.											
Vs*: Vinland-----	0-17 17	Silty clay loam Weathered bedrock.	ML, CL ---	A-6, A-7 ---	0 ---	85-100 ---	85-100 ---	80-100 ---	75-95 ---	35-50 ---	10-25 ---
Sogn-----	0-9 9	Silty clay loam Unweathered bedrock.	CL ---	A-6, A-7 ---	0-10 ---	85-100 ---	85-100 ---	85-100 ---	80-95 ---	25-45 ---	11-23 ---

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group
							K	T	
	In	In/hr	In/in	pH	Mmhos/cm				
Ab----- Albaton	0-8 8-60	<0.2 <0.2	0.11-0.13 0.11-0.13	7.4-8.4 7.4-8.4	<2 <2	High----- High-----	0.28 0.28	5	4
At*: Aquents									
Co----- Colo	0-10 10-60	0.6-2.0 0.2-0.6	0.22-0.24 0.18-0.20	6.6-7.3 6.1-7.3	<2 <2	Moderate High-----	0.37 0.37	5	6
Gb, Gc----- Grundy	0-13 13-19 19-30 30-60	0.6-2.0 0.2-0.6 0.06-0.2 0.06-0.2	0.22-0.24 0.18-0.20 0.11-0.13 0.18-0.20	5.6-7.3 5.6-6.5 5.1-7.3 5.6-7.3	<2 <2 <2 <2	Moderate High----- High----- High-----	0.37 0.37 0.37 0.37	4	6
Ha----- Hamburg	0-11 11-60	0.6-2.0 0.6-2.0	0.20-0.24 0.17-0.22	7.4-8.4 7.4-8.4	<2 <2	Low----- Low-----	0.43 0.43	5	4L
Hn----- Haynie	0-8 8-60	0.6-2.0 0.6-2.0	0.18-0.20 0.16-0.19	6.6-8.4 7.4-8.4	<2 <2	Low----- Low-----	0.37 0.37	5	6
Ho*: Haynie	0-8 8-60	0.6-2.0 0.6-2.0	0.18-0.20 0.16-0.19	6.6-8.4 7.4-8.4	<2 <2	Low----- Low-----	0.37 0.37	5	6
Onawa-----	0-8 8-26 26-60	0.06-0.2 0.06-0.2 0.6-6.0	0.12-0.14 0.12-0.14 0.20-0.22	7.4-8.4 7.4-8.4 7.9-8.4	<2 <2 <2	High----- High----- Moderate	0.43 0.32 0.43	5	7
Hs*: Haynie	0-8 8-60	0.6-2.0 0.6-2.0	0.18-0.20 0.16-0.19	6.6-8.4 7.4-8.4	<2 <2	Low----- Low-----	0.37 0.37	5	6
Sarpy-----	0-5 5-64	>6.0 >6.0	0.05-0.09 0.05-0.09	6.6-8.4 7.4-8.4	<2 <2	Low----- Low-----	0.17 0.15	5	2
Ju----- Judson	0-13 13-60	0.6-2.0 0.6-2.0	0.21-0.23 0.21-0.23	6.1-7.3 6.1-7.8	<2 <2	Moderate Moderate	0.32 0.43	5	6
Ke, Kf----- Kennebec	0-46 46-60	0.6-2.0 0.6-2.0	0.22-0.24 0.20-0.22	5.6-7.3 6.1-7.3	<2 <2	Moderate Moderate	0.32 0.43	5	6
Kn, Ko, Kp----- Knox	0-8 8-53 53-60	0.6-2.0 0.6-2.0 0.6-2.0	0.22-0.24 0.18-0.20 0.20-0.22	5.6-7.3 5.6-7.3 6.1-7.3	<2 <2 <2	Moderate Moderate Moderate	0.32 0.43 0.43	5	6
Ma, Mb----- Marshall	0-7 7-60	0.6-2.0 0.6-2.0	0.21-0.23 0.18-0.20	5.6-7.3 5.6-7.3	<2 <2	Moderate Moderate	0.32 0.43	5	6
Mc----- Martin	0-7 7-51 51	0.2-0.6 0.06-0.2 ---	0.21-0.23 0.12-0.18 ---	5.6-6.5 5.6-7.8 ---	<2 <2 ---	Moderate High----- ---	0.37 0.37 ---	4	7
Md, Me, Mf----- Monona	0-11 11-25 25-60	0.6-2.0 0.6-2.0 0.6-2.0	0.22-0.24 0.20-0.22 0.20-0.22	5.6-7.3 6.1-7.3 6.6-8.4	<2 <2 <2	Moderate Moderate Moderate	0.32 0.43 0.43	5	6
Mh*: Monona	0-11 11-25 25-60	0.6-2.0 0.6-2.0 0.6-2.0	0.22-0.24 0.20-0.22 0.20-0.22	5.6-7.3 6.1-7.3 6.6-8.4	<2 <2 <2	Moderate Moderate Moderate	0.32 0.43 0.43	5	6
Hamburg-----	0-11 11-60	0.6-2.0 0.6-2.0	0.20-0.24 0.17-0.22	7.4-8.4 7.4-8.4	<2 <2	Low----- Low-----	0.43 0.43	5	4L

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group
							K	T	
	In	In/hr	In/in	pH	Mmhos/cm				
Mo, Mp, Ms-----	0-5	0.6-2.0	0.14-0.21	5.1-6.5	<2	Low-----	0.28	5	6
Morrill	5-54	0.2-0.6	0.15-0.19	5.1-6.5	<2	Moderate	0.28		
	54-60	0.2-2.0	0.15-0.18	5.1-7.3	<2	Low-----	0.37		
Od-----	0-16	0.6-6.0	0.22-0.24	7.9-8.4	<2	Moderate	0.43	5	6
Onawa	16-38	0.06-0.2	0.12-0.14	7.4-8.4	<2	High-----	0.32		
	38-60	0.6-6.0	0.20-0.22	7.9-8.4	<2	Moderate	0.43		
On-----	0-8	0.06-0.2	0.12-0.14	7.4-8.4	<2	High-----	0.43	5	7
Onawa	8-26	0.06-0.2	0.12-0.14	7.4-8.4	<2	High-----	0.32		
	26-60	0.6-6.0	0.20-0.22	7.9-8.4	<2	Moderate	0.43		
Pt*. Pits									
Re-----	0-14	0.6-2.0	0.21-0.23	5.6-7.3	<2	Low-----	0.32	5	6
Reading	14-46	0.2-2.0	0.18-0.20	5.6-7.3	<2	Moderate	0.43		
	46-60	0.2-2.0	0.13-0.20	6.1-8.4	<2	Moderate	0.43		
Sa-----	0-5	>6.0	0.05-0.09	6.6-8.4	<2	Low-----	0.17	5	2
Sarpy	5-60	>6.0	0.05-0.09	7.4-8.4	<2	Low-----	0.15		
Vr*: Vinland-----	0-17	0.6-2.0	0.21-0.24	5.6-7.8	<2	Moderate	0.32	2	7
	17	---	---	---	---	---	---		
Rock outcrop.									
Vs*: Vinland-----	0-17	0.6-2.0	0.21-0.24	5.6-7.8	<2	Moderate	0.32	2	7
	17	---	---	---	---	---	---		
Sogn-----	0-9	0.6-2.0	0.17-0.22	6.1-8.4	<2	Moderate	0.32	1	4L
	9	---	---	---	---	---	---		

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--SOIL AND WATER FEATURES

[The definitions of "flooding" and "water table" in the text explain terms such as "rare," "brief," "apparent," and "perched."
The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth <u>Ft</u>	Kind	Months	Depth <u>In</u>	Hardness		Uncoated steel	Concrete
Ab----- Albaton	D	Occasional	Brief to long.	Mar-Jun	1.0-3.0	Apparent	Nov-May	>60	---	Moderate	High-----	Low.
At*. Aquets												
Co----- Colo	B/D	Occasional	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Moderate
Gb, Gc----- Grundy	C	None-----	---	---	1.0-3.0	Perched	Mar-May	>60	---	High-----	High-----	Moderate
Ha----- Hamburg	B	None-----	---	---	>6.0	---	---	>60	---	High-----	Low-----	Low.
Hn----- Haynie	B	Occasional	Very brief	Mar-Jun	4.0-6.0	Perched	Oct-Jun	>60	---	High-----	Low-----	Low.
Ho*; Haynie-----	B	Occasional	Very brief	Mar-Jun	4.0-6.0	Perched	Oct-Jun	>60	---	High-----	Low-----	Low.
Onawa-----	D	Occasional	Brief to long.	Mar-Jun	2.0-4.0	Apparent	Nov-May	>60	---	High-----	High-----	Low.
Hs*; Haynie-----	B	Occasional	Very brief	Mar-Jun	4.0-6.0	Perched	Oct-Jun	>60	---	High-----	Low-----	Low.
Sarpy-----	A	Occasional	Brief to long.	Nov-Jun	>6.0	---	---	>60	---	Low-----	Low-----	Low.
Ju----- Judson	B	None-----	---	---	>6.0	---	---	>60	---	High-----	Moderate	Low.
Ke----- Kennebec	B	Occasional	Brief-----	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	High-----	Moderate	Low.
Kf----- Kennebec	B	Frequent----	Brief-----	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	High-----	Moderate	Low.
Kn, Ko, Kp----- Knox	B	None-----	---	---	>6.0	---	---	>60	---	High-----	Low-----	Low.
Ma, Mb----- Marshall	B	None-----	---	---	>6.0	---	---	>60	---	High-----	Moderate	Moderate
Mc----- Martin	C	None-----	---	---	>6.0	---	---	>40	Wippable	High-----	High-----	Low.
Md, Me, Mf----- Monona	B	None-----	---	---	>6.0	---	---	>60	---	High-----	Low-----	Low.
Mh*; Monona-----	B	None-----	---	---	>6.0	---	---	>60	---	High-----	Low-----	Low.

See footnote at end of table.

TABLE 15.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth <u>Ft</u>	Kind	Months	Depth <u>In</u>	Hardness		Uncoated steel	Concrete
Mh#: Hamburg-----	B	None-----	---	---	>6.0	---	---	>60	---	High-----	Low-----	Low.
Mo, Mp, Ms----- Morrill	B	None-----	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate
Od, On----- Onawa	D	Occasional	Brief-----	Mar-Jun	2.0-4.0	Apparent	Nov-May	>60	---	High-----	High-----	Low.
Pt#. Pits												
Re----- Reading	C	Rare-----	---	---	3.5-6.0	Perched	Dec-Apr	>60	---	High-----	Moderate	Low.
Sa----- Sarpy	A	Occasional	Brief to long.	Nov-Jun	>6.0	---	---	>60	---	Low-----	Low-----	Low.
Vr#: Vinland----- Rock outcrop.	D	None-----	---	---	>6.0	---	---	10-20	Rippable	Moderate	Moderate	Low.
Vs#: Vinland-----	D	None-----	---	---	>6.0	---	---	10-20	Rippable	Moderate	Moderate	Low.
Sogn-----	D	None-----	---	---	>6.0	---	---	4-20	Hard	Moderate	Low-----	Low.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--CLASSIFICATION OF THE SOILS

[An asterisk in the first column indicates that the soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series]

Soil name	Family or higher taxonomic class
Albaton-----	Fine, montmorillonitic (calcareous), mesic Vertic Fluvaquents
Aquents-----	Clayey and loamy, mixed, mesic Typic Fluvaquents
Colo-----	Fine-silty, mixed, mesic Cumulic Haplaquolls
*Grundy-----	Fine, montmorillonitic, mesic Aquic Argiudolls
Hamburg-----	Coarse-silty, mixed (calcareous), mesic Typic Udorthents
Haynie-----	Coarse-silty, mixed (calcareous), mesic Mollic Udifluvents
Judson-----	Fine-silty, mixed, mesic Cumulic Hapludolls
Kennebec-----	Fine-silty, mixed, mesic Cumulic Hapludolls
Knox-----	Fine-silty, mixed, mesic Mollic Hapludalfs
Marshall-----	Fine-silty, mixed, mesic Typic Hapludolls
Martin-----	Fine, montmorillonitic, mesic Aquic Argiudolls
Monona-----	Fine-silty, mixed, mesic Typic Hapludolls
Morrill-----	Fine-loamy, mixed, mesic Typic Argiudolls
Onawa-----	Clayey over loamy, montmorillonitic (calcareous), mesic Mollic Fluvaquents
Reading-----	Fine-silty, mixed, mesic Typic Argiudolls
Sarpy-----	Mixed, mesic Typic Udipsamments
Sogn-----	Loamy, mixed, mesic Lithic Haplustolls
Vinland-----	Loamy, mixed, mesic, shallow Typic Hapludolls

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NEBRASKA

RICHARDSON
COUNTY

T. 1 S.

T. 2 S.

T. 3 S.

T. 4 S.

COUNTY

BROWN

ATCHISON

COUNTY

R. 19 E.

R. 20 E.

T. 5 S.

R. 21 E.

MISSOURI

HOLT

95°10

95°00

ANDREW

COUNTY

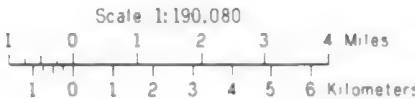
COUNTY

R. 22 E.
R. 23 E.

MISSOURI

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
KANSAS AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
DONIPHAN COUNTY, KANSAS



SOIL LEGEND

- 1 Monona association: Deep, gently sloping to moderately steep, well drained soils that have a silt loam subsoil; on uplands
- 2 Hamburg-Monona association: Deep, moderately steep and steep, somewhat excessively drained and well drained soils that have a silt loam subsoil; on uplands
- 3 Knox-Monona association: Deep, moderately sloping to moderately steep, well drained soils that have a silt loam and silty clay loam subsoil; on uplands
- 4 Marshall-Morrill-Grundy association: Deep, nearly level to strongly sloping, well drained and somewhat poorly drained soils that have a clay loam to silty clay subsoil; on uplands
- 5 Marshall-Monona-Morrill association: Deep, moderately sloping to moderately steep, well drained soils that have a silty clay loam, silt loam, and clay loam subsoil; on uplands
- 6 Knox-Marshall-Vinland association: Deep or shallow, moderately sloping to moderately steep, well drained and somewhat excessively drained soils that have a silty clay loam and silt loam subsoil; on uplands
- 7 Onawa-Haynie-Albaton association: Deep, nearly level, moderately well drained to poorly drained soils that have a silt loam to silty clay subsoil; on flood plains
- 8 Kennebec-Colo-Judson association: Deep, nearly level and gently sloping, moderately well drained, poorly drained, and well drained soils that have a silt loam and silty clay loam subsoil; on flood plains, terraces, and foot slopes

Compiled 1979

SECTIONALIZED
TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

NEBRASKA

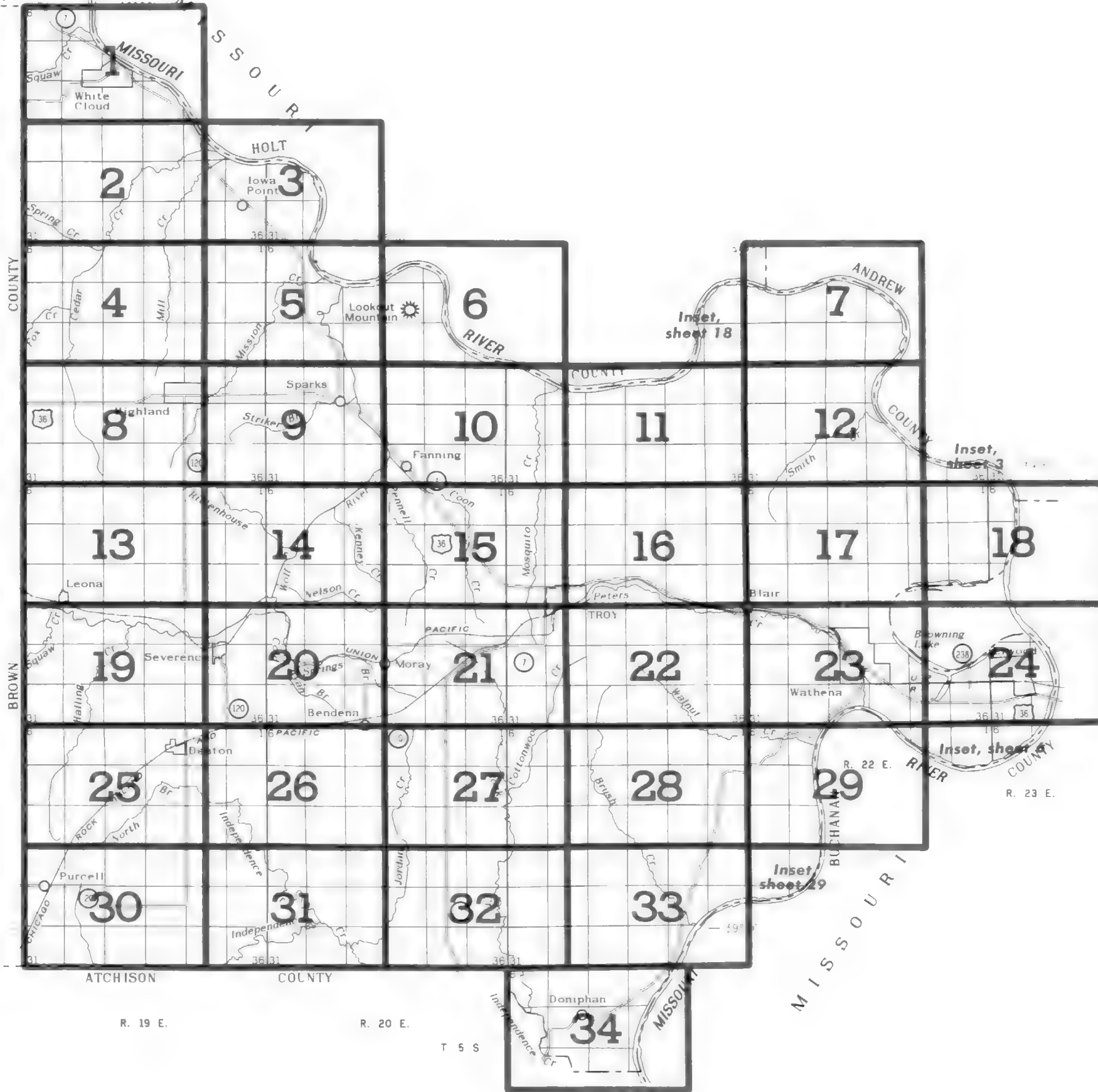
RICHARDSON COUNTY

T. 1 S.

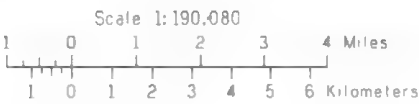
T. 2 S.

T. 3 S.

T. 4 S.



INDEX TO MAP SHEETS
DONIPHAN COUNTY, KANSAS



SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

CONVENTIONAL AND SPECIAL
SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES	
National, state or province	
County or parish	
Minor civil division	
Reservation (national forest or park, state forest or park, and large airport)	
Land grant	
Limit of soil survey (label)	
Field sheet matchline & neatline	
AD HOC BOUNDARY (label)	
Small airport, airfield, park, oilfield, cemetery, or flood pool	
STATE COORDINATE TICK	
LAND DIVISION CORNERS (sections and land grants)	
ROADS	
Divided (median shown if scale permits)	
Other roads	
Trail	
ROAD EMBLEMS & DESIGNATIONS	
Interstate	
Federal	
State	
County, farm or ranch	
RAILROAD	
POWER TRANSMISSION LINE (normally not shown)	
PIPE LINE (normally not shown)	
FENCE (normally not shown)	
LEVEES	
Without road	
With road	
With railroad	
LAKES	
Large (to scale)	
Medium or small	
PITS	
Gravel pit	
Mine or quarry	

MISCELLANEOUS CULTURAL FEATURES	
Farmstead, house (omit in urban areas)	
Church	
School	
Indian mound (label)	
Located object (label)	
Tank (label)	
Wells, oil or gas	
Windmill	
Kitchen midden	

WATER FEATURES

DRAINAGE	
Perennial, double line	
Perennial, single line	
Intermittent	
Drainage end	
Canals or ditches	
Double-line (label)	
Drainage and/or irrigation	
LAKES, PONDS AND RESERVOIRS	
Perennial	
Intermittent	
MISCELLANEOUS WATER FEATURES	
Marsh or swamp	
Spring	
Well, artesian	
Well, irrigation	
Wet spot	

SPECIAL SYMBOLS FOR
SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS	
ESCARPMENTS	
Bedrock (points down slope)	
Other than bedrock (points down slope)	
SHORT STEEP SLOPE	
GULLY	
DEPRESSION OR SINK	
SOIL SAMPLE SITE (normally not shown)	
MISCELLANEOUS	
Blowout	
Clay spot	
Gravelly spot	
Gumbo, slick or scabby spot (sodic)	
Dumps and other similar non soil areas	
Prominent hill or peak	
Rock outcrop (includes sandstone and shale)	
Saline spot	
Sandy spot	
Severely eroded spot	
Slide or slip (tips point upslope)	
Stony spot, very stony spot	

SOIL LEGEND

SYMBOL	NAME
Ab	Atbaton silty clay
At	Aquents
Co	Colo silt loam
Gb	Grundy silty clay loam, 0 to 2 percent slopes
Gc	Grundy silty clay loam, 2 to 6 percent slopes
Ha	Hamburg silt loam, 25 to 50 percent slopes
Hn	Haynie silt loam
Ho	Haynie-Onawa complex
Hs	Haynie-Sarpy complex
Ju	Judson silt loam, 1 to 3 percent slopes
Ke	Kennebec silt loam
Kf	Kennebec silt loam, channeled
Kn	Knox silt loam, 4 to 10 percent slopes, eroded
Ko	Knox silt loam, 10 to 18 percent slopes, eroded
Kp	Knox silt loam, 18 to 30 percent slopes, eroded
Ma	Marshall silt loam, 1 to 3 percent slopes
Mb	Marshall silt loam, 3 to 7 percent slopes
Mc	Martin silty clay loam, 3 to 7 percent slopes, eroded
Md	Monona silt loam, 3 to 10 percent slopes
Me	Monona silt loam, 3 to 10 percent slopes, eroded
Mf	Monona silt loam, 10 to 18 percent slopes, eroded
Mh	Monona-Hamburg silt loams, 18 to 30 percent slopes, eroded
Mo	Morrill loam, 2 to 7 percent slopes, eroded
Mp	Morrill loam, 7 to 12 percent slopes, eroded
Ms	Morrill loam, 12 to 18 percent slopes, eroded
Od	Onawa loam
On	Onawa silty clay loam
Pt	Pits, quarries
Re	Reading silt loam
Sa	Sarpy loamy fine sand
Vr	Vinland-Rock outcrop complex, 20 to 40 percent slopes
Vs	Vinland-Sogn silty clay loams, 4 to 15 percent slopes

RICHARDSON COUNTY, NEBRASKA

R 19 E

BROWN COUNTY

T 1 S

HOLT COUNTY, MISSOURI

MISSOURI RIVER

MISSOURI RIVER

INDEFINITE BOUNDARY

White Cloud

CLIVE BRANCH CEMETERY

1

N

1 MILE

1 KILOMETER

Scale 1:20000

605 000 FEET

3/4

1/2

1/4

0

0

0

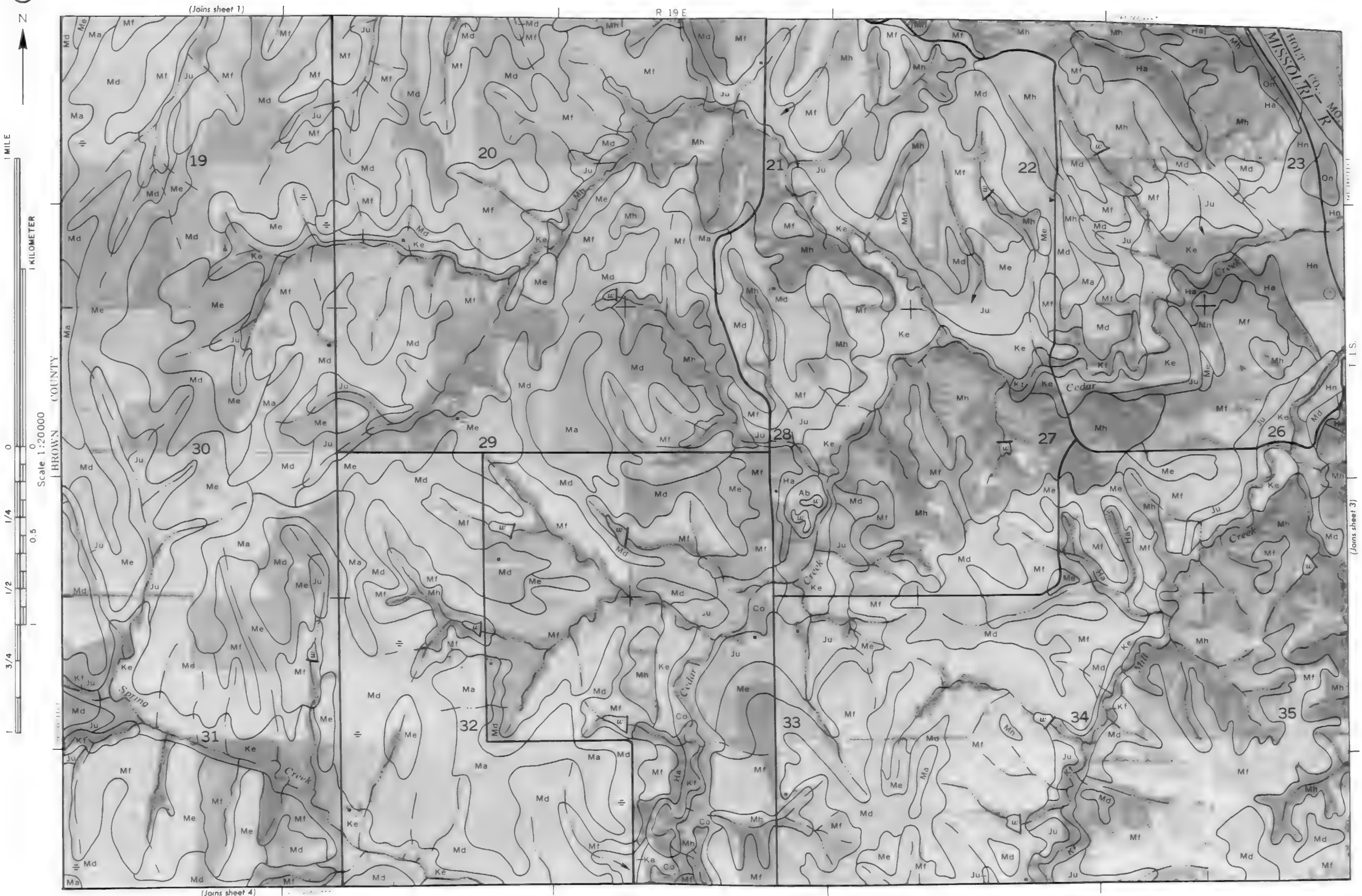
0

0

0

0

(Joins sheet 2)





(Joins sheet 2)

R 19 E



1 MILE

1 KILOMETER

BROWN COUNTY

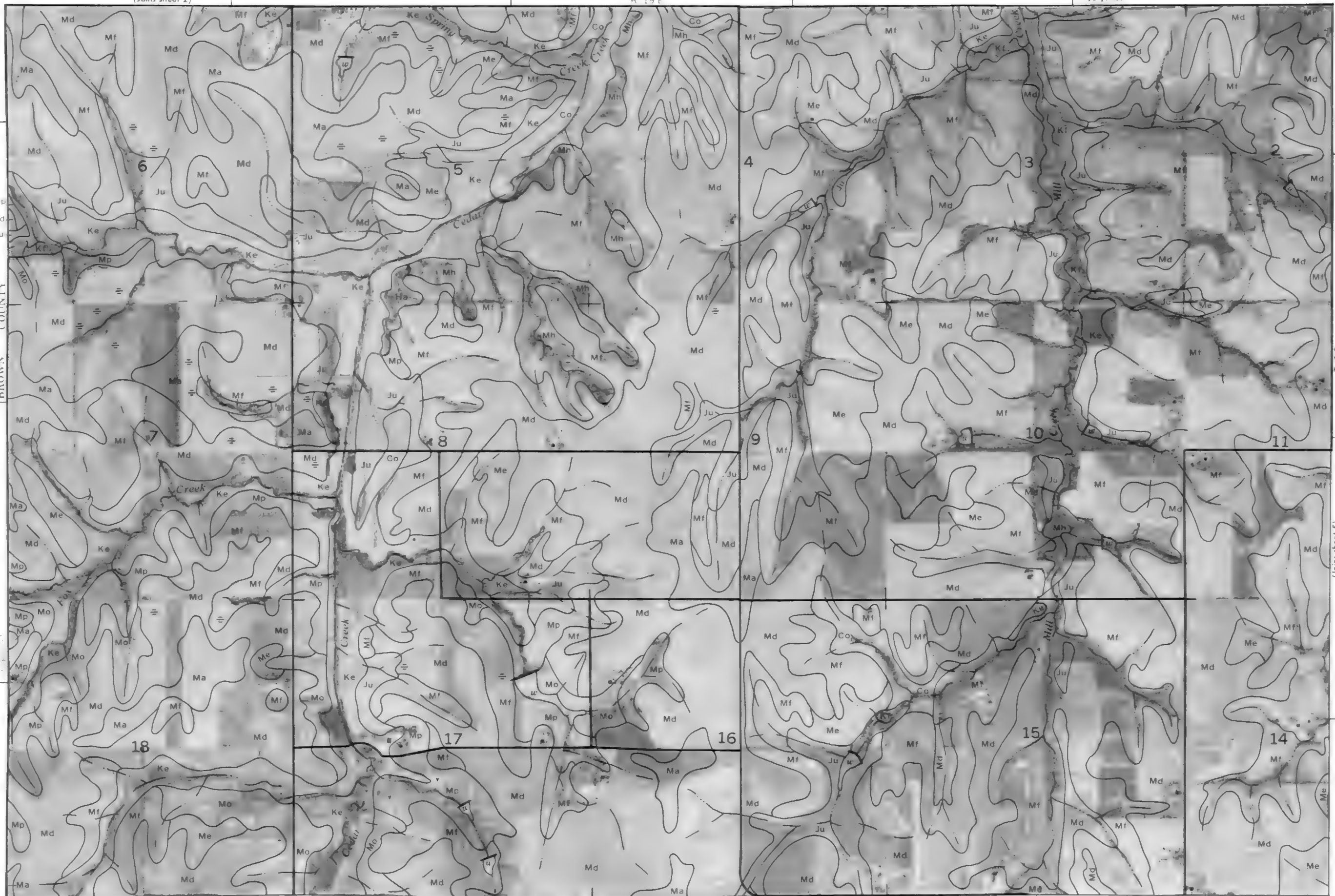
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1/4 0.5

1/2

3/4

1



(Joins sheet 8)

(Joins sheet 5)



1 KILOMETER

○

50

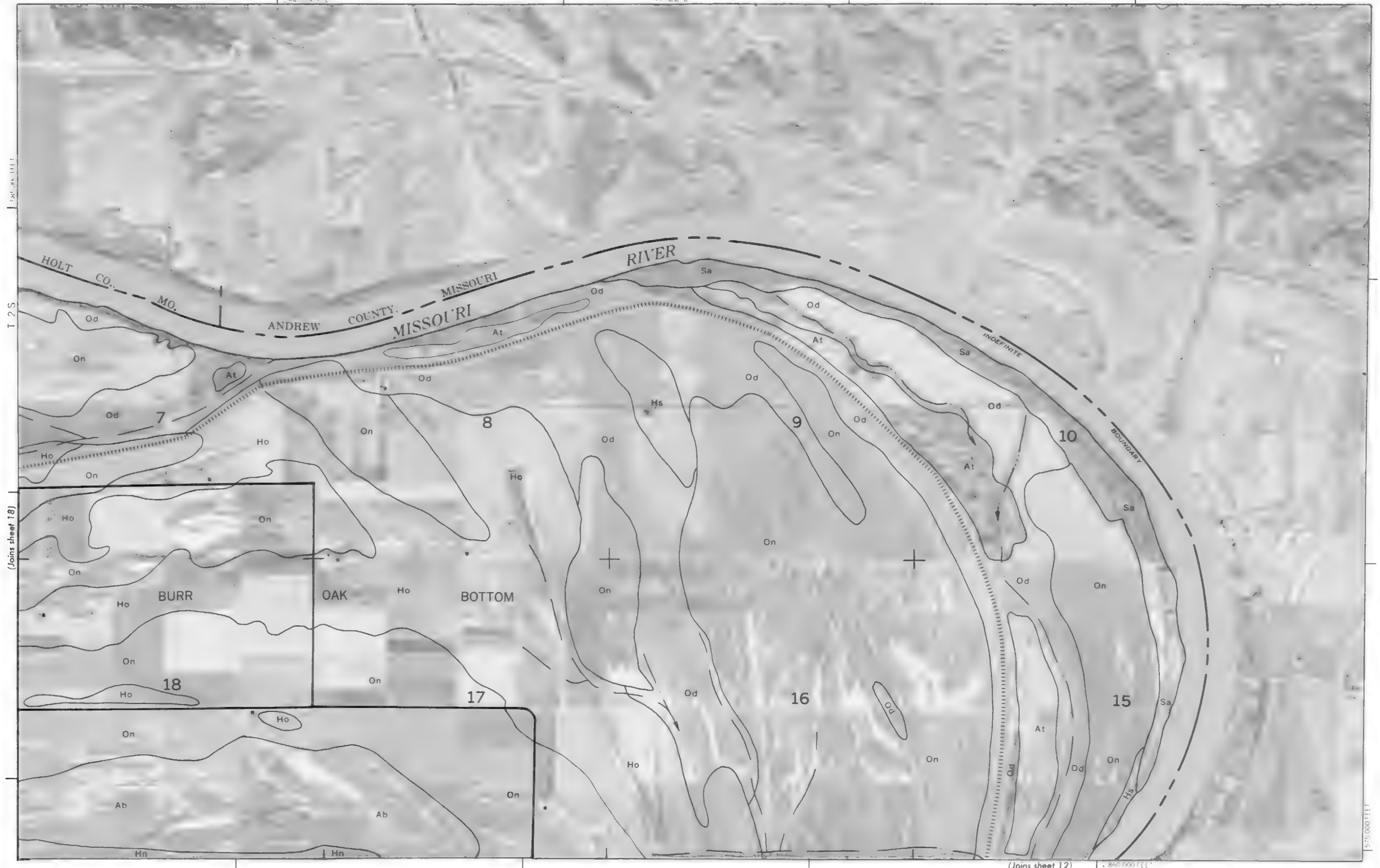
1



R 22 E

T 2 S

(Joins sheet 18)



1 MILE

1 KILOMETER

Scale 1:20000

0 1/4 1/2 3/4 1

0 0.5 1

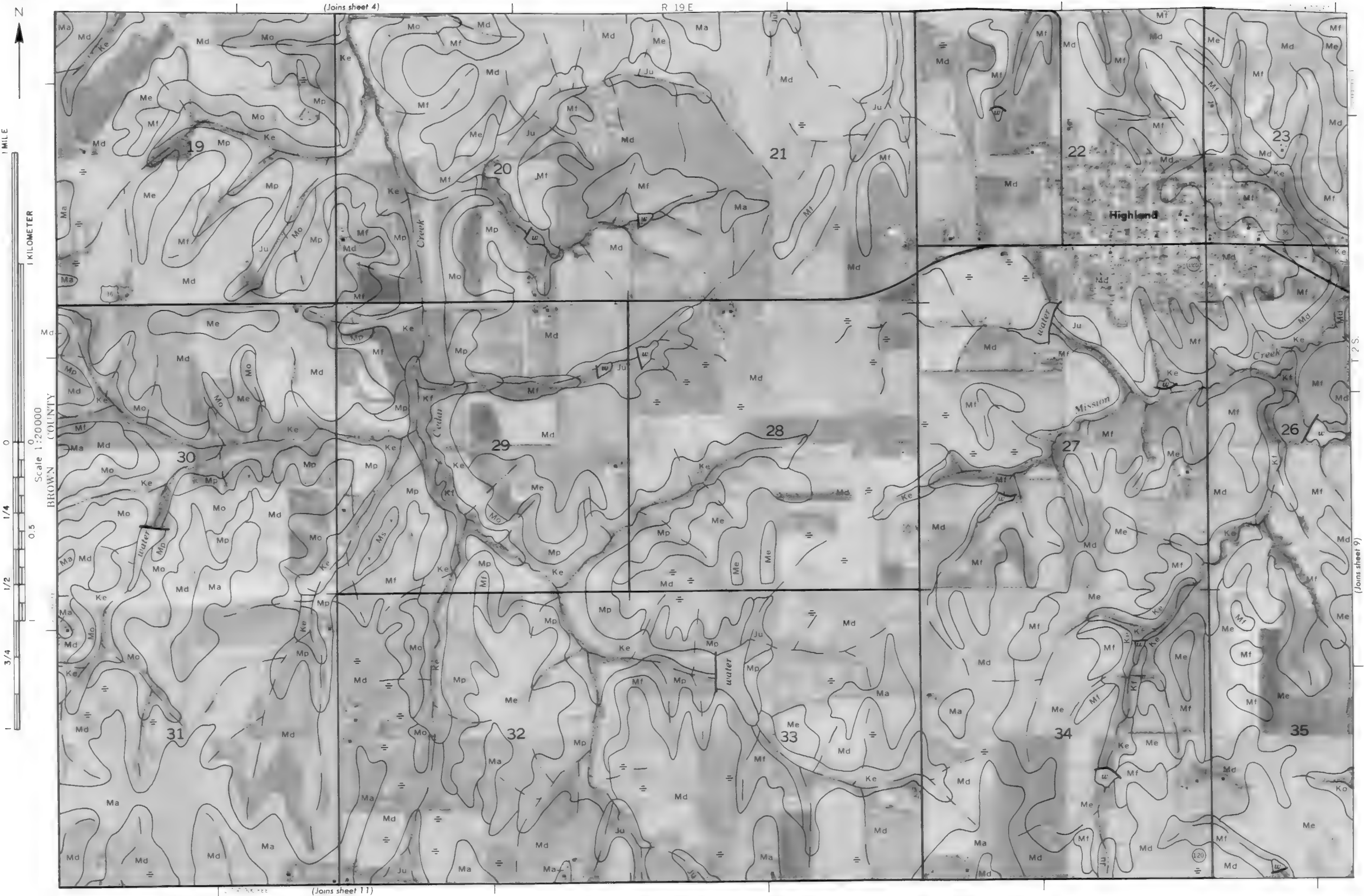
0 0.5 1

0 0.5 1

575,000 FEET

(Joins sheet 12)

575,000 FEET





(Joins sheet 6)



1 MILE



1 KILOMETER



0

1/4

0.5

1/2

1

1/4

0.5

1

1/4

0.5

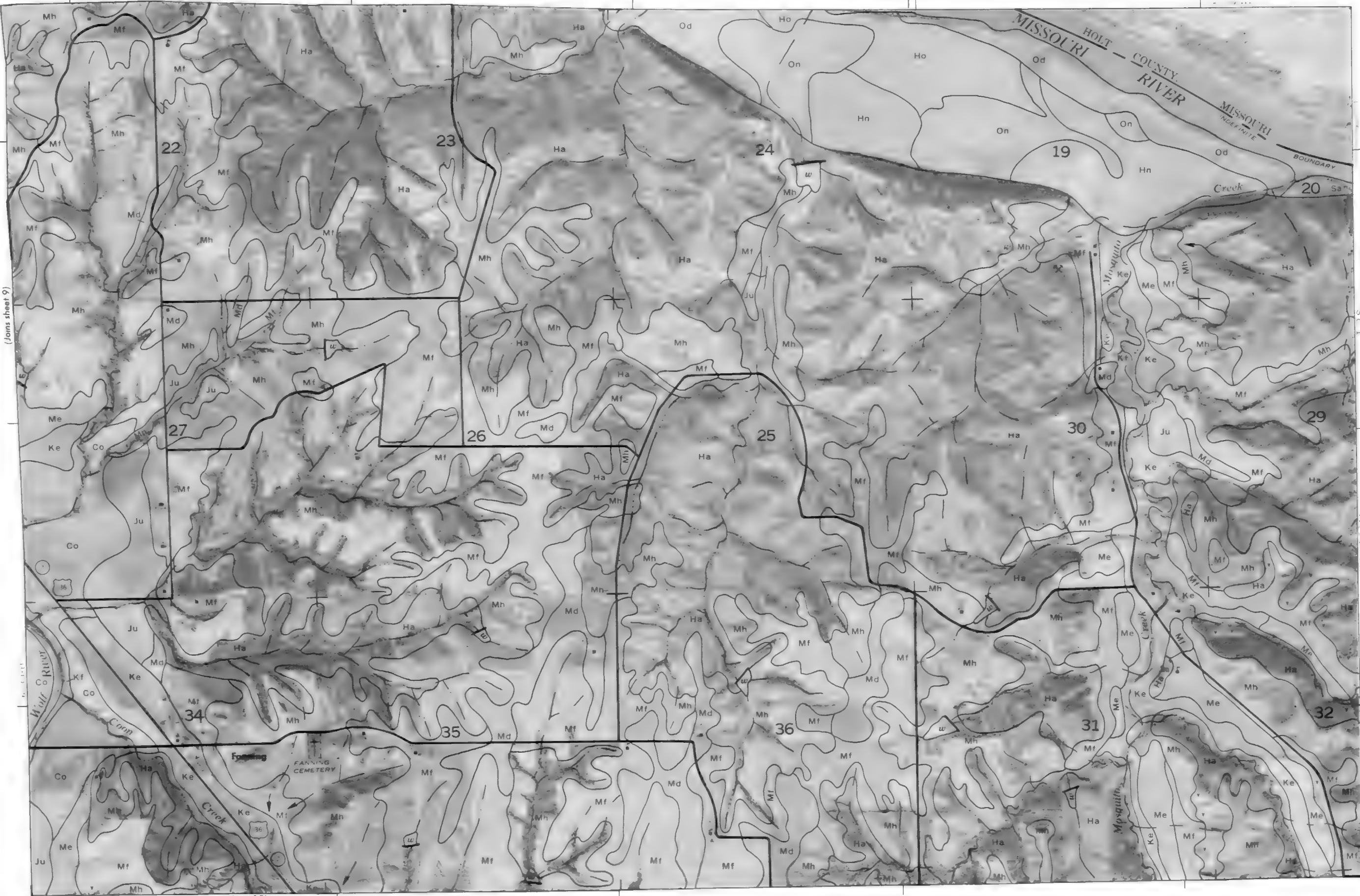
1

1/4

0.5

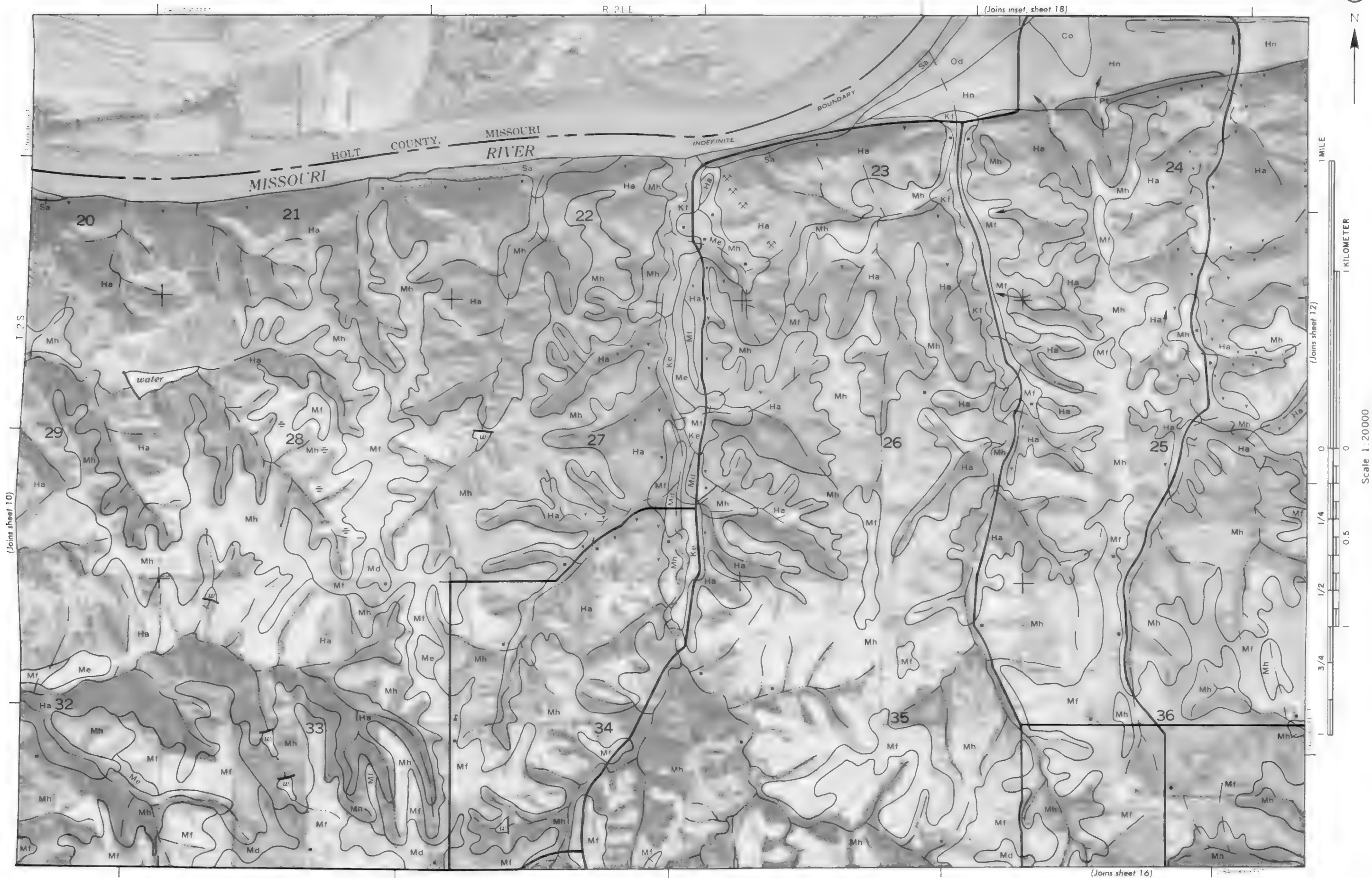
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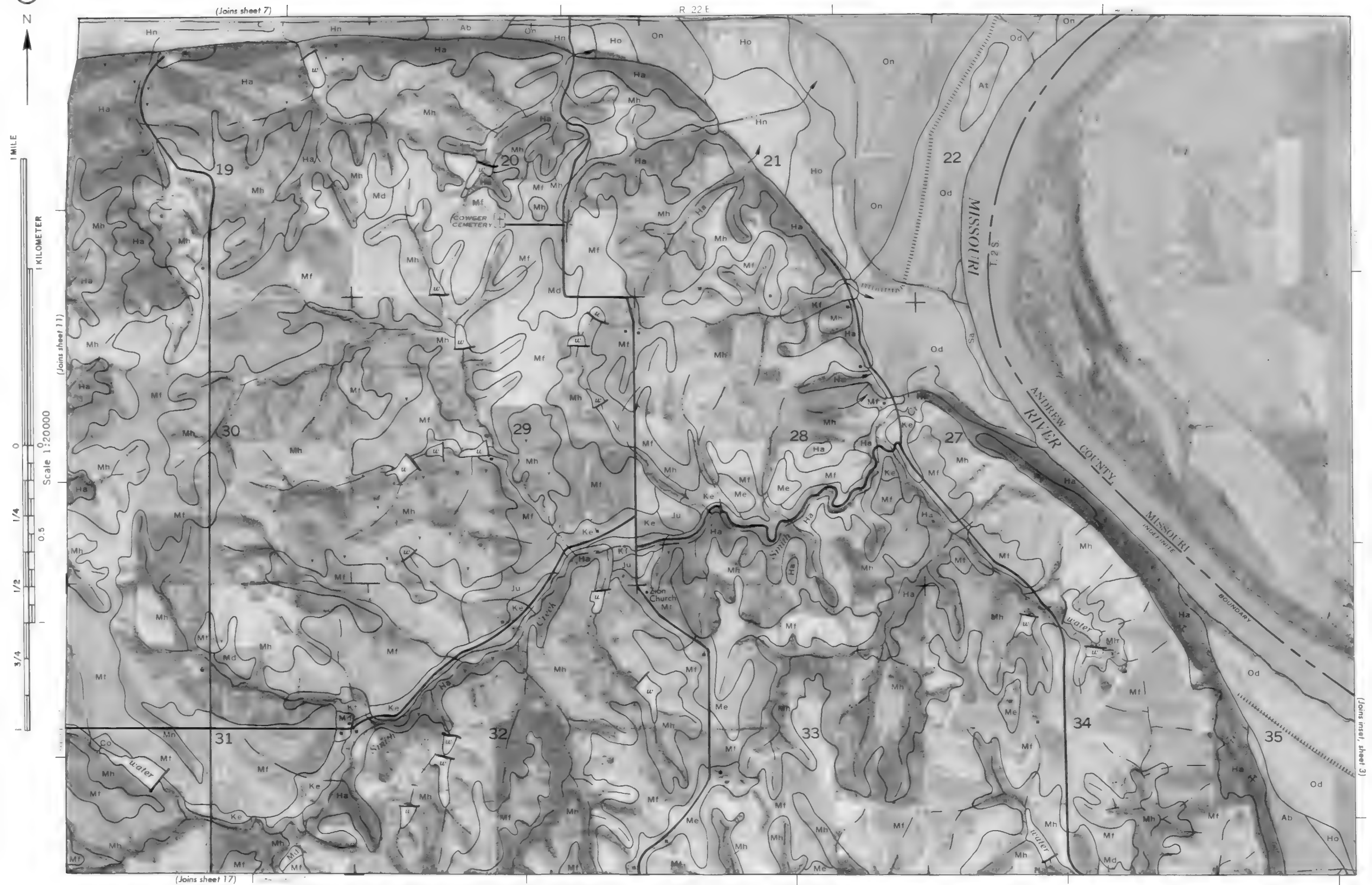
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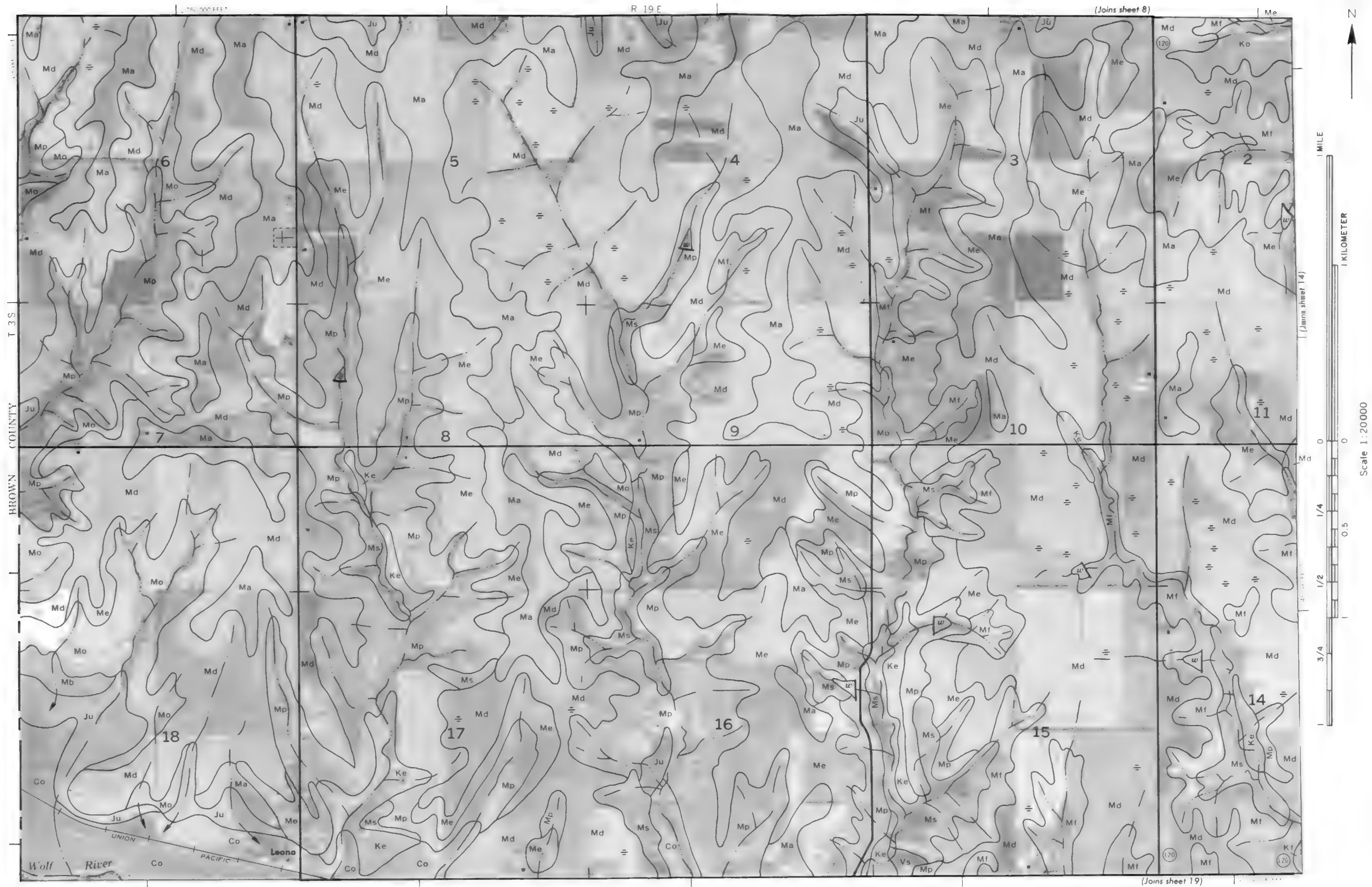


(Joins sheet 15)

(Joins sheet 11)







14

(Joins sheet 9)

R 19 E

R 20 E



1 MILE

1 KILOMETER

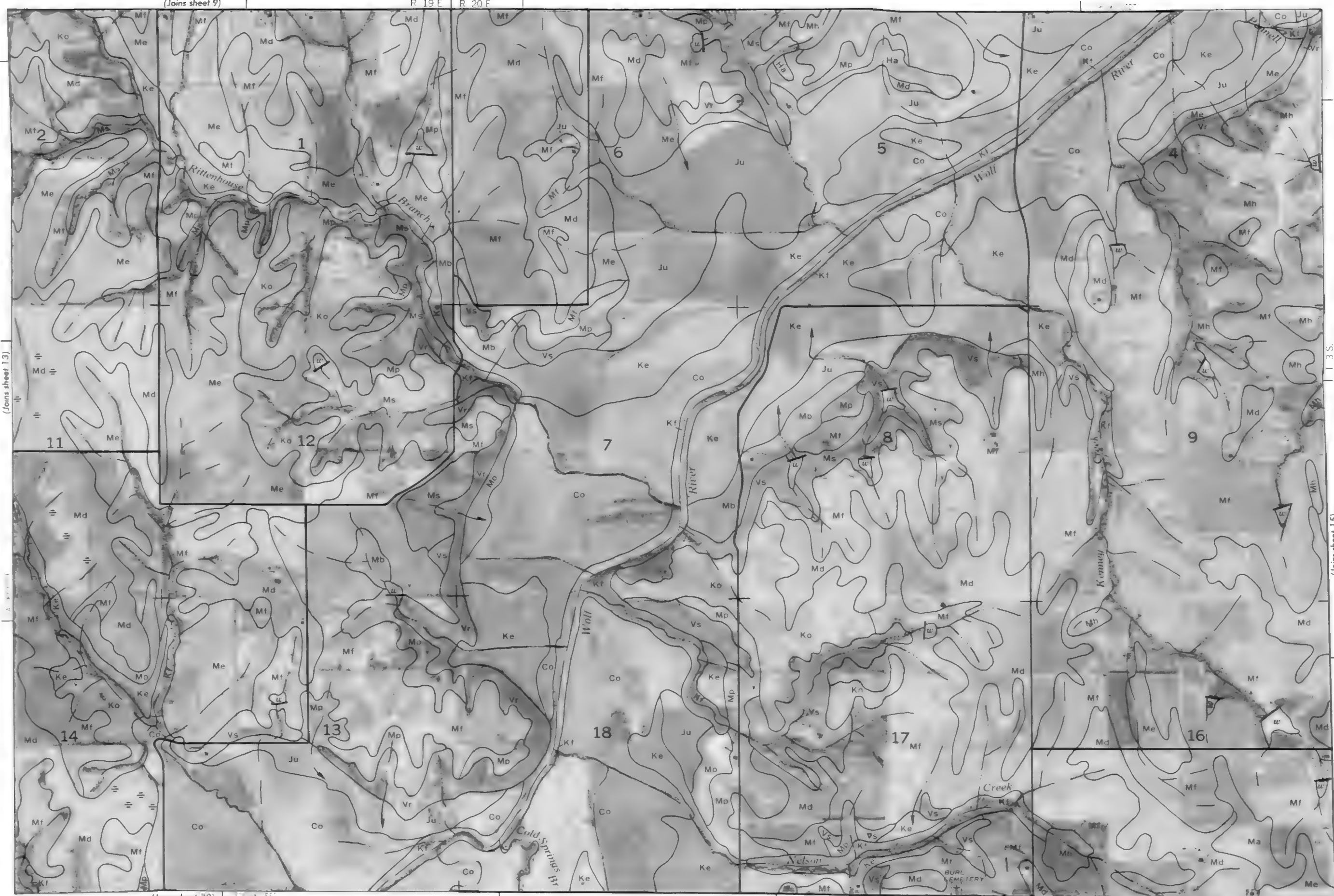
Scale 1:200000

1/4

0.5

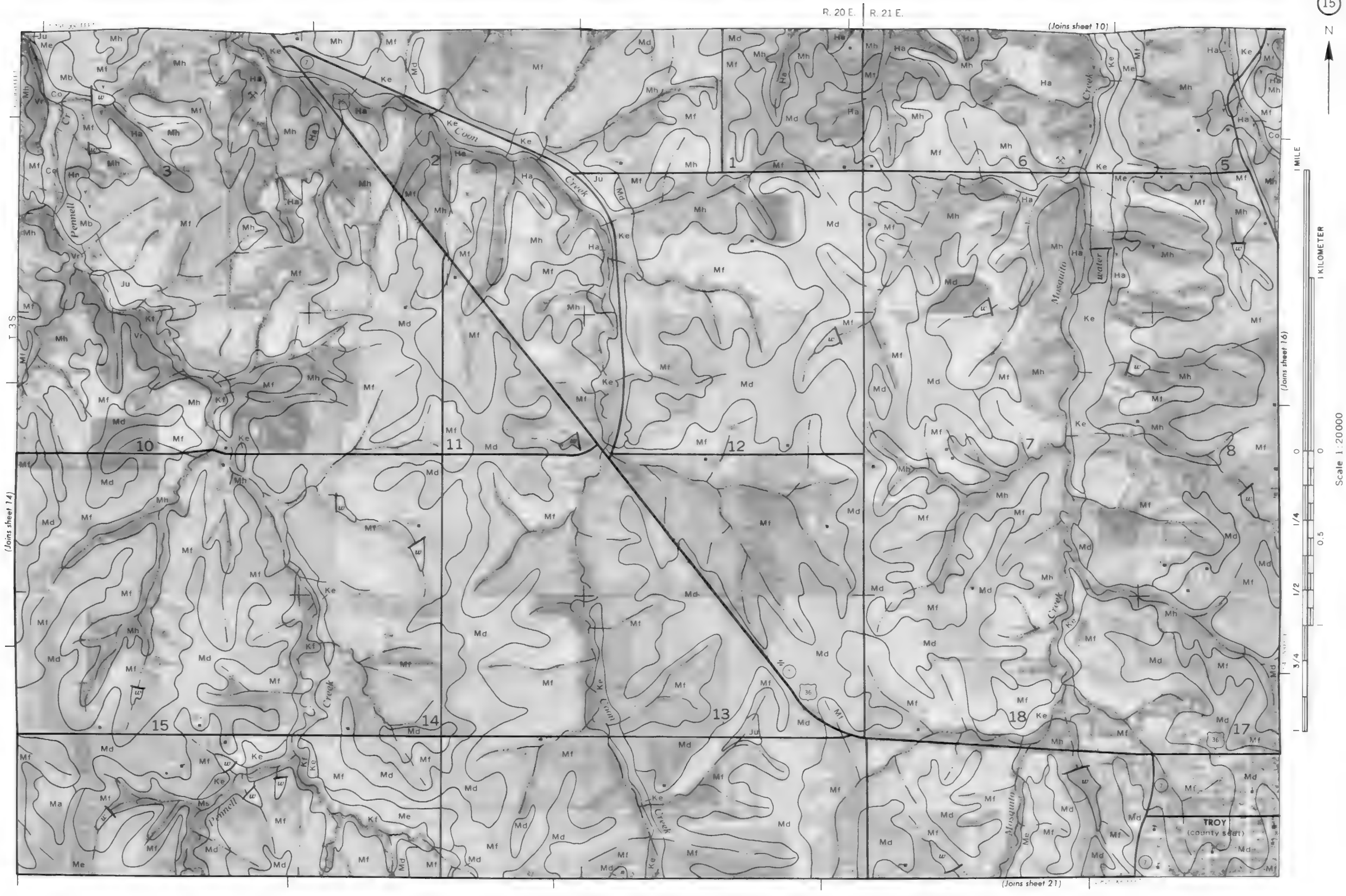
1/2

3/4

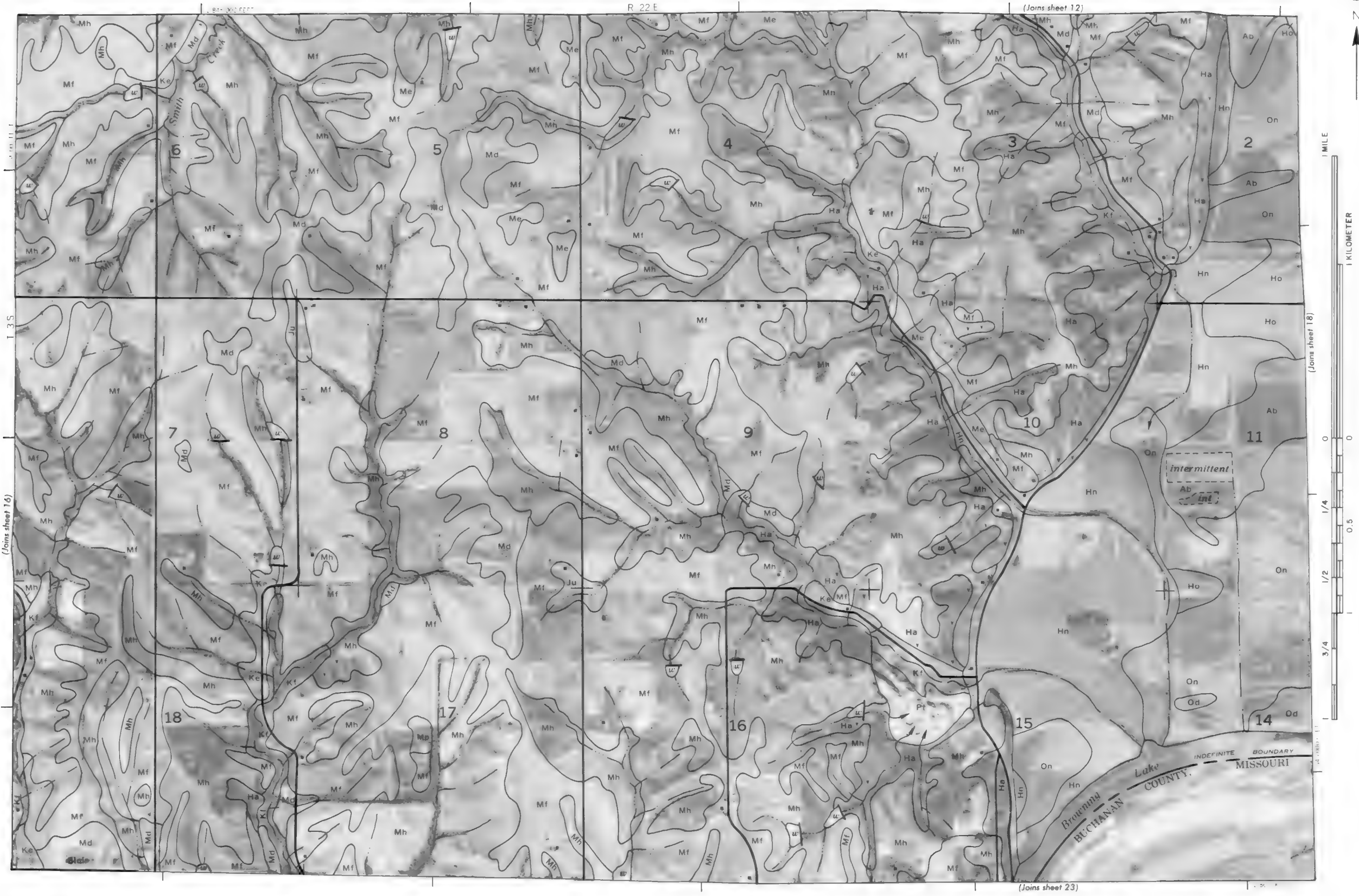


(Joins sheet 20)

(Joins sheet 15)







(Joins inset, sheet 3)

R. 22 E. | R. 23 E.

2 875 000 FEET



1 MILE



1 KILOMETER

(Joins sheet 17)

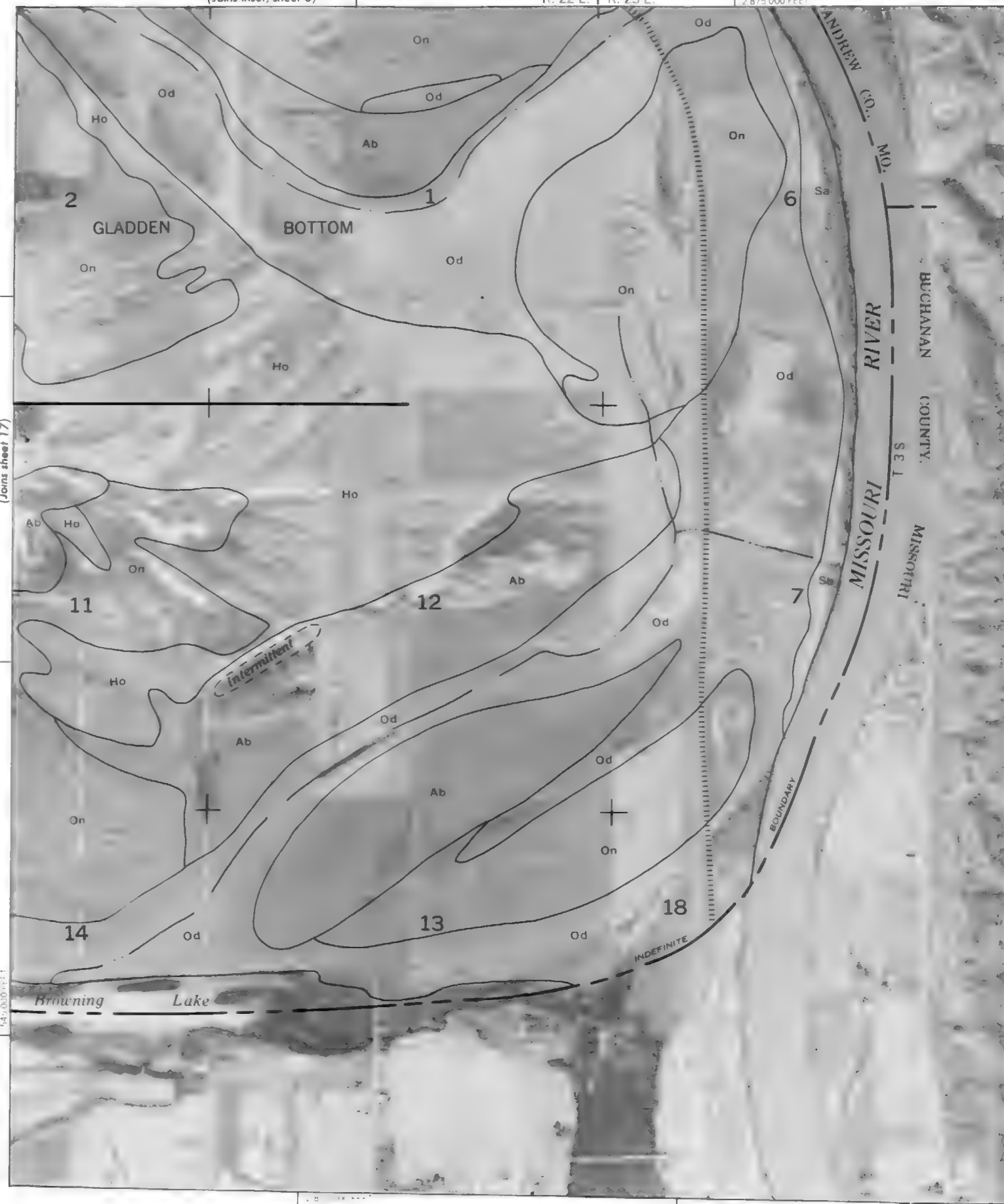
Scale 1:20000

0 1/4 0.5

1/2

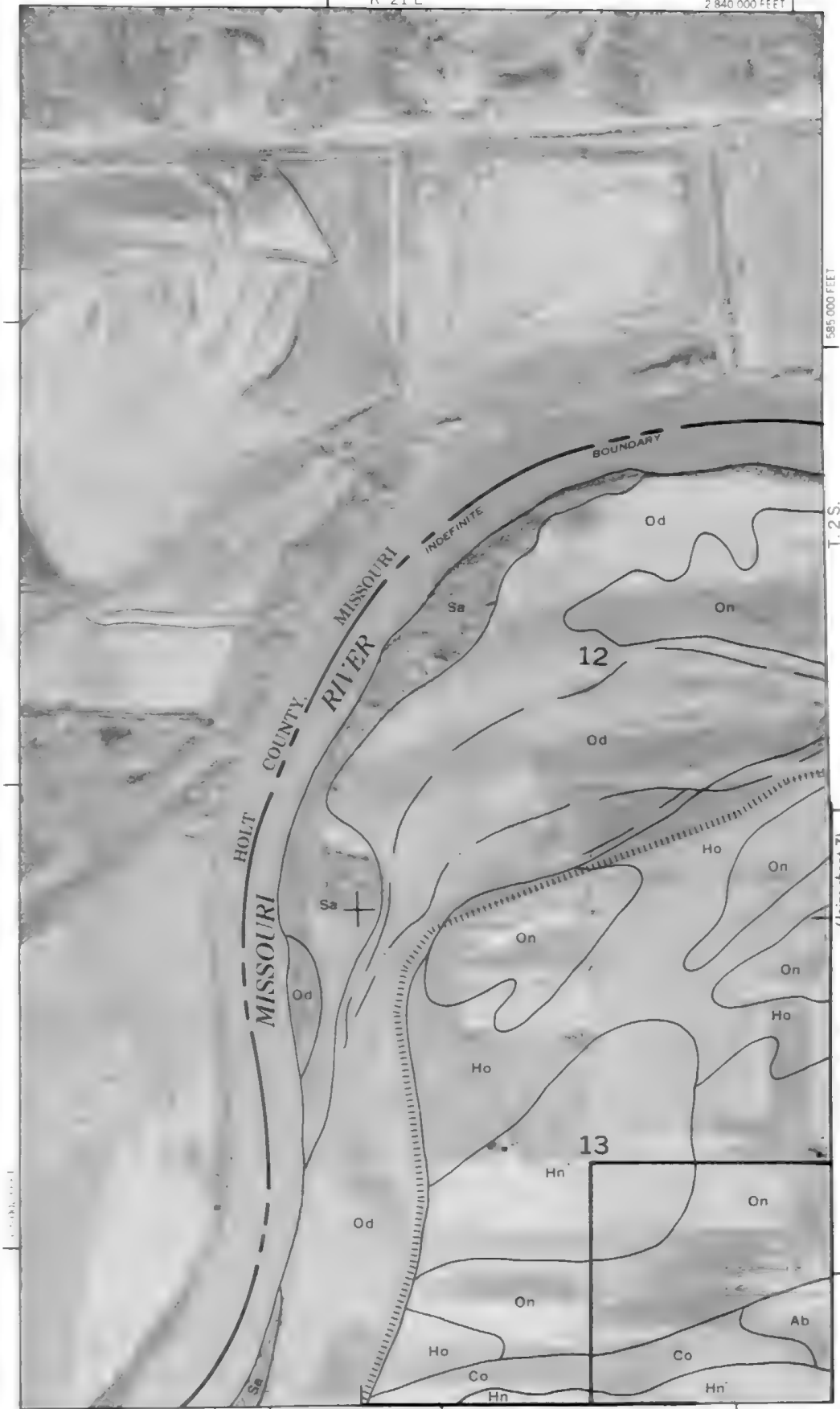
3/4

1

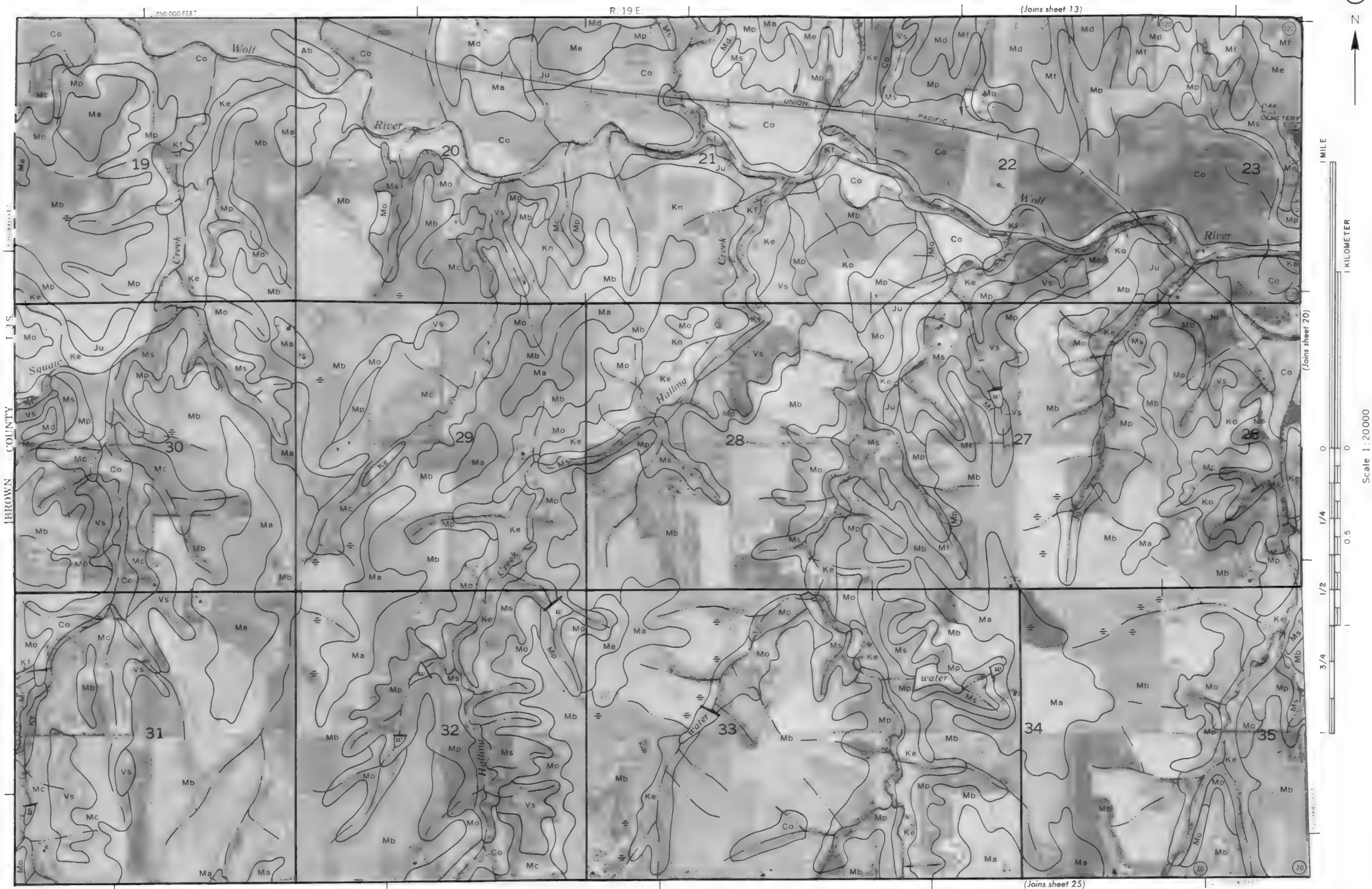


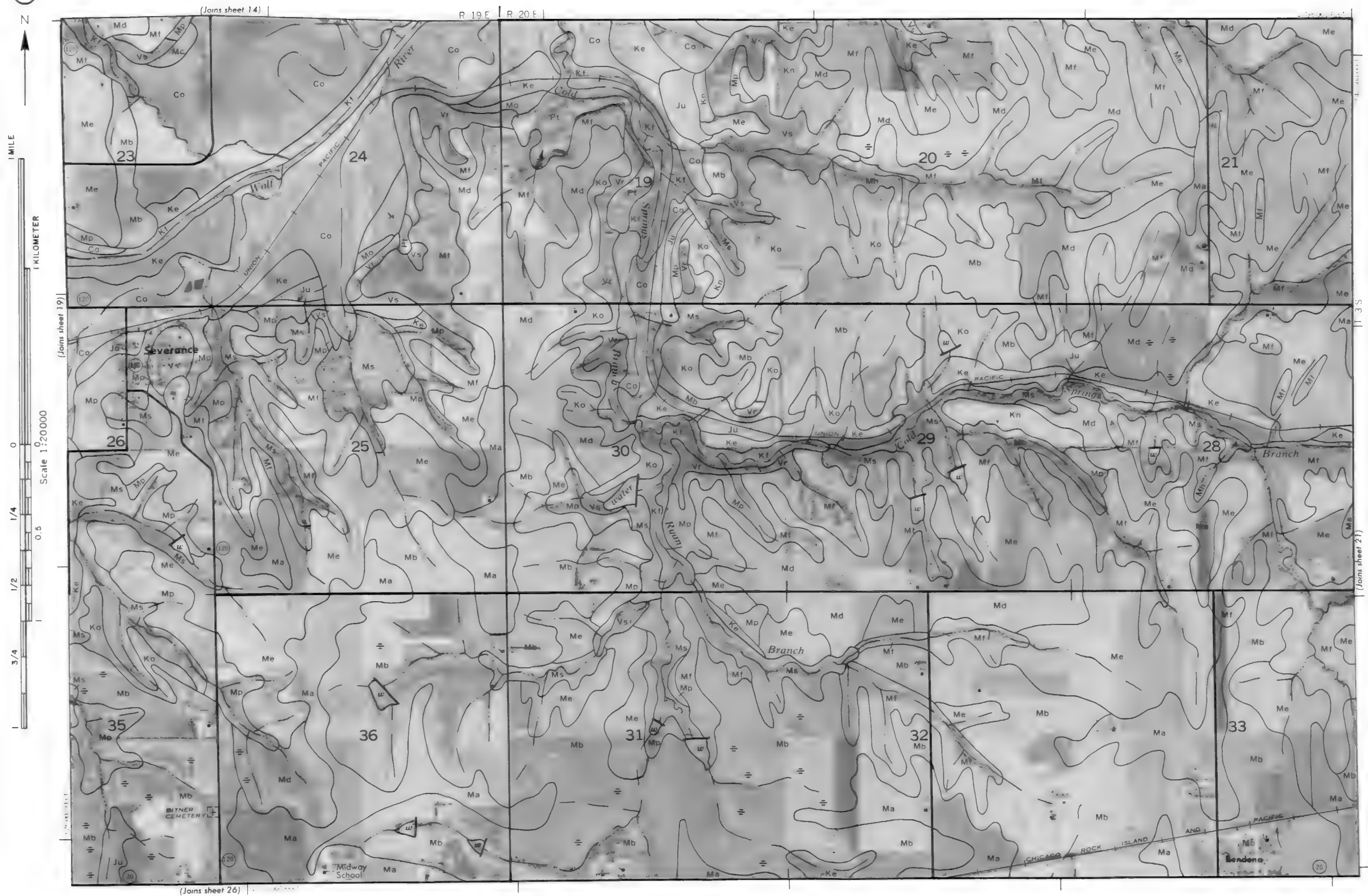
R. 21 E.

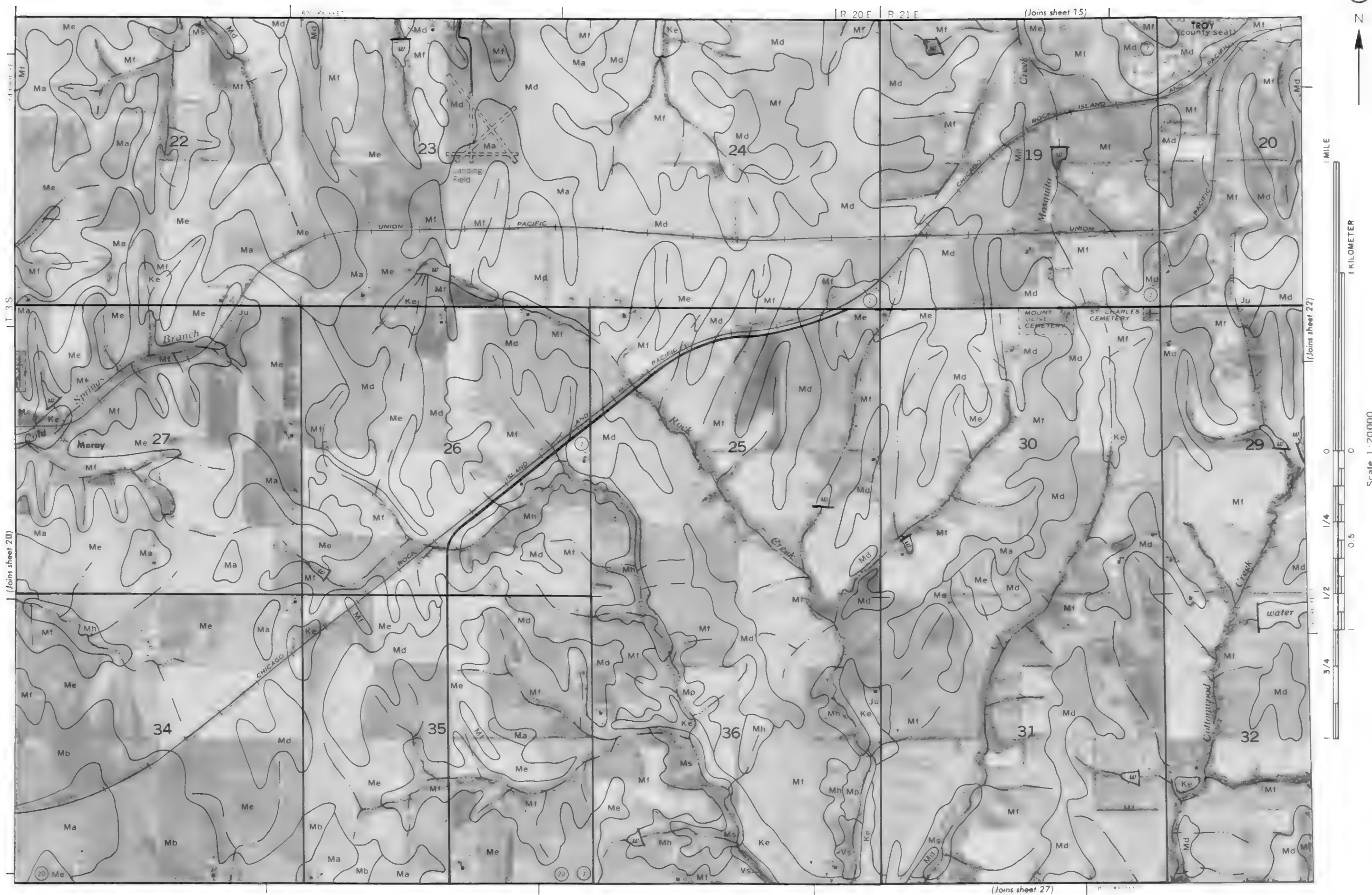
2 840 000 FEET

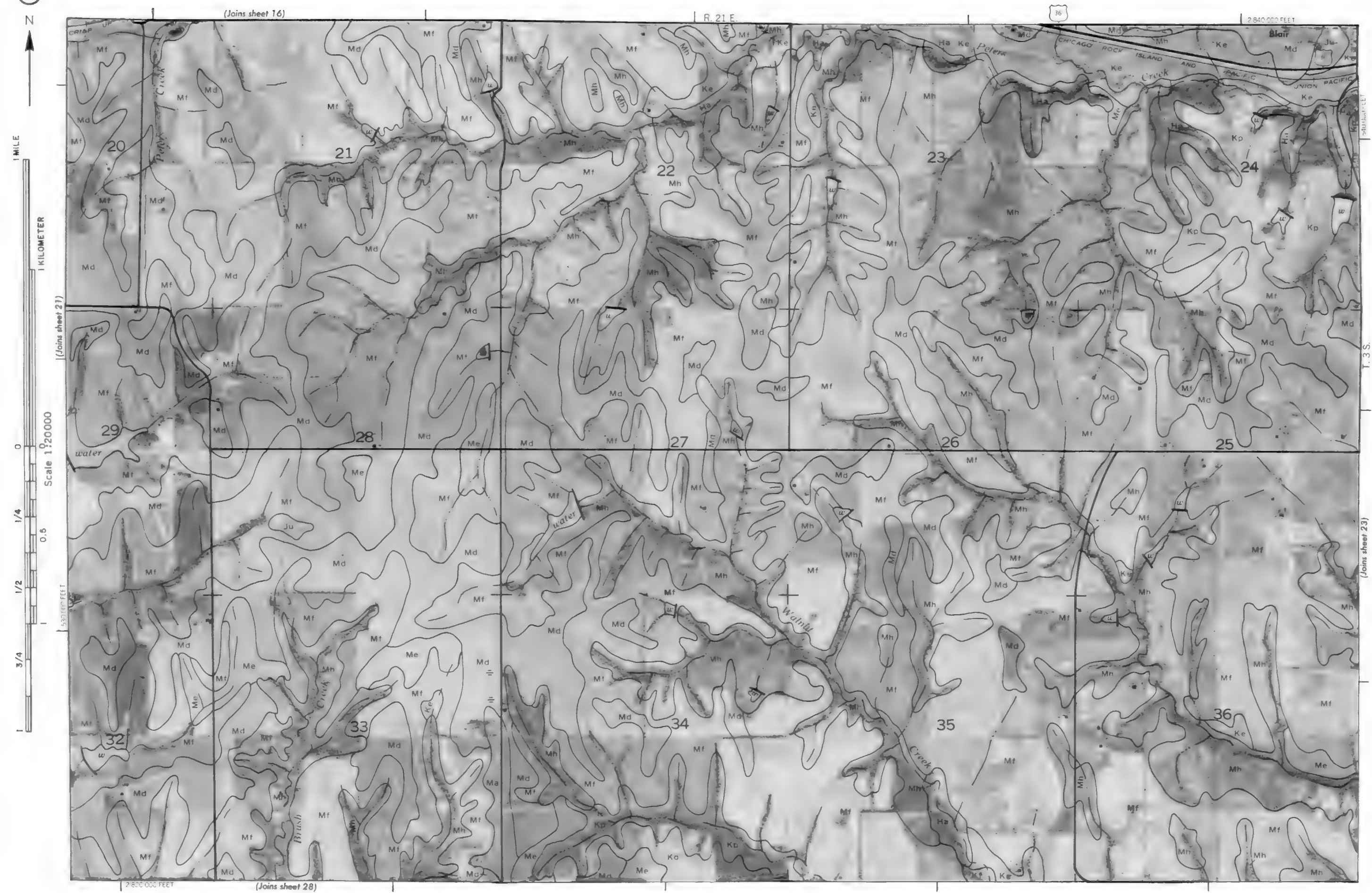


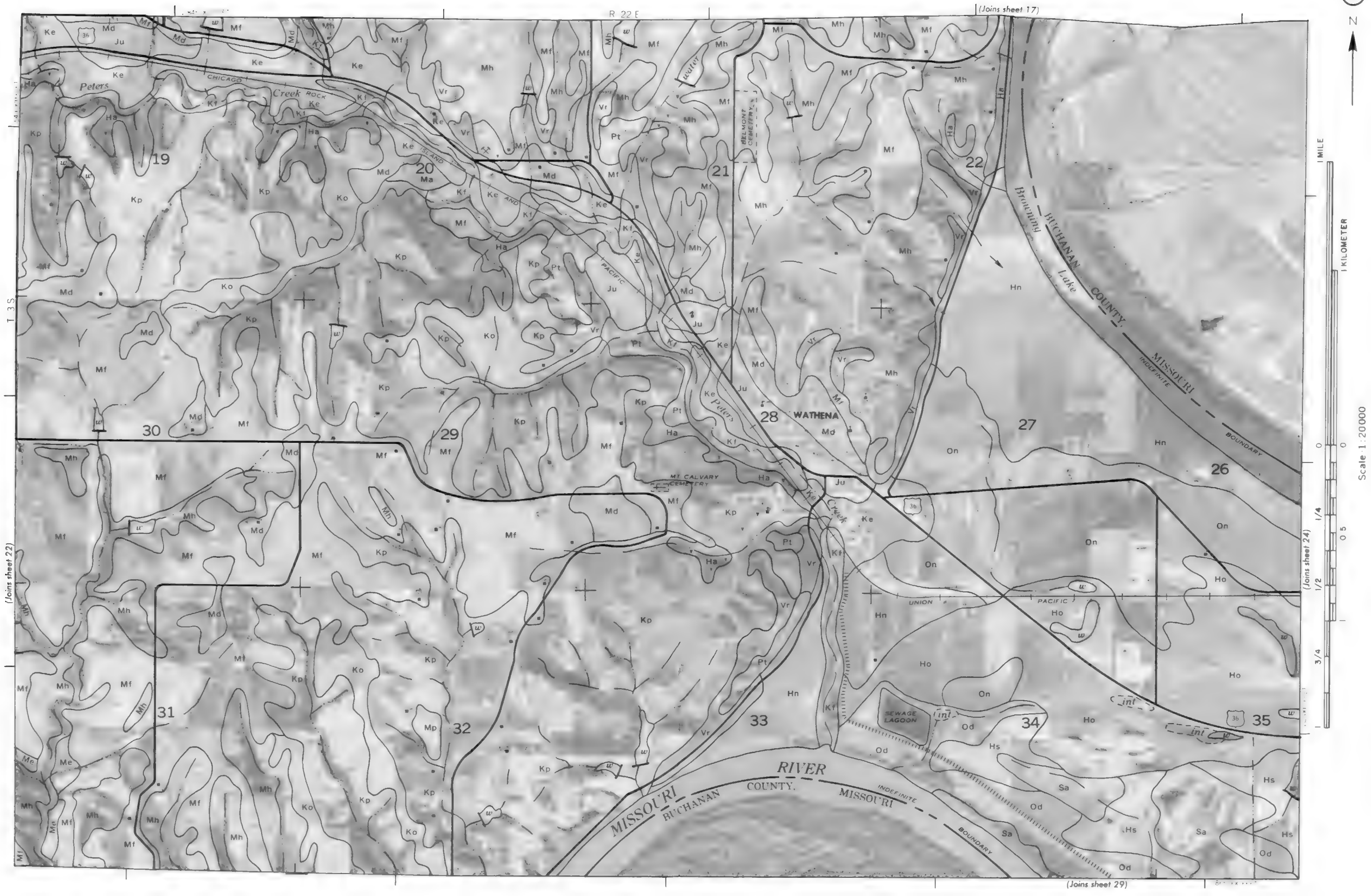
(Joins sheet 11)













R. 22 E. | R. 23 E.

1 MILE



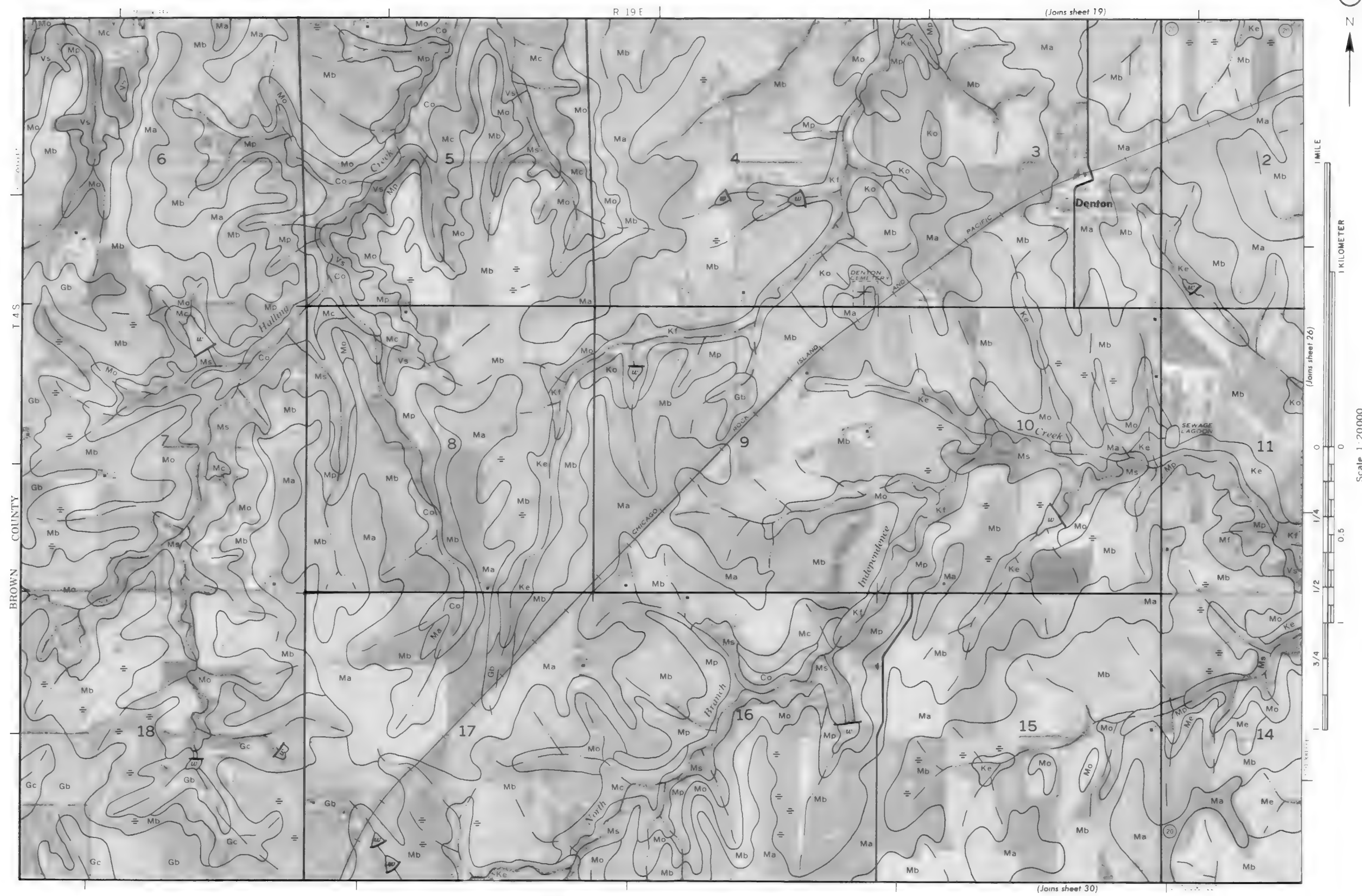
1 KILOMETER

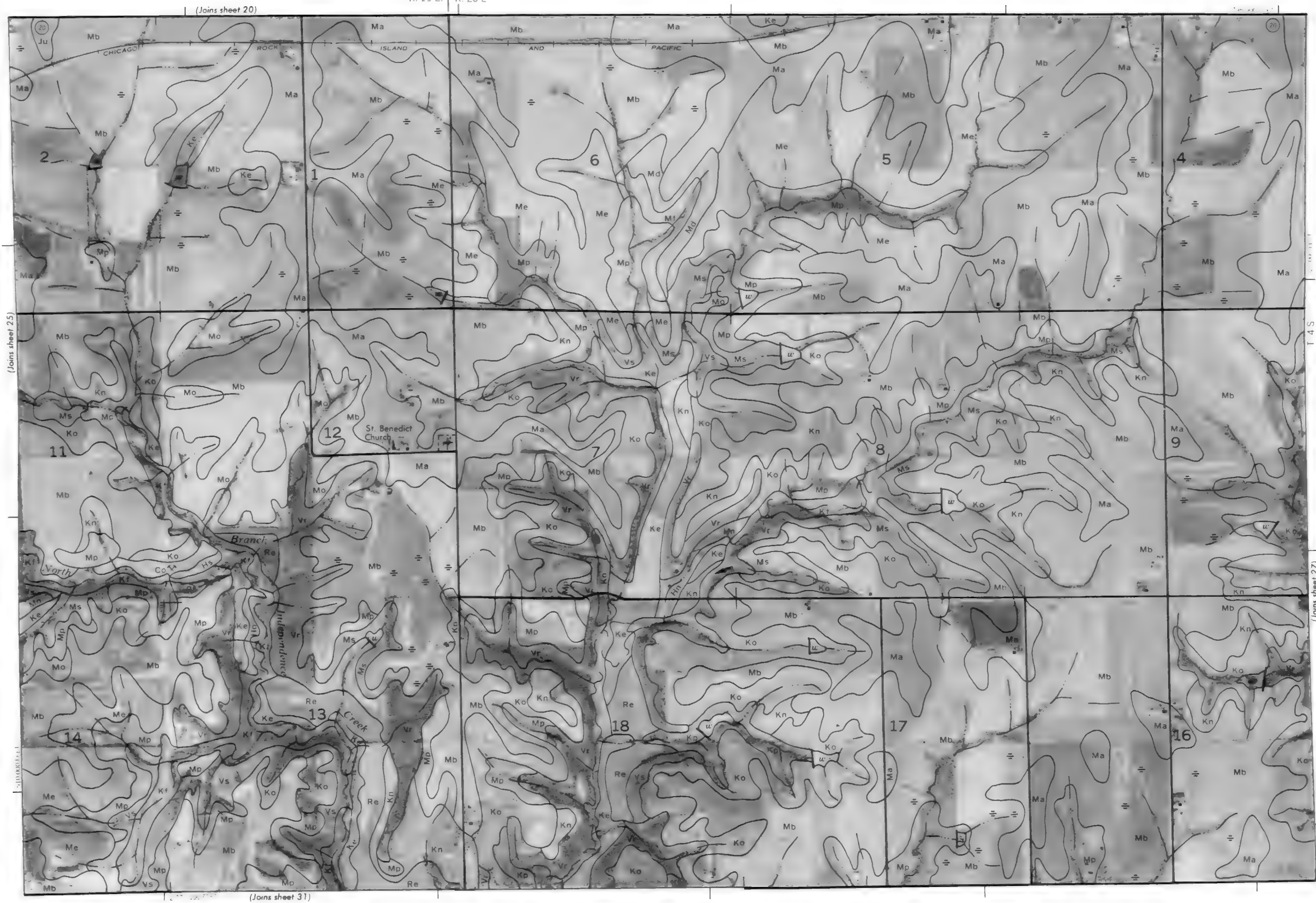
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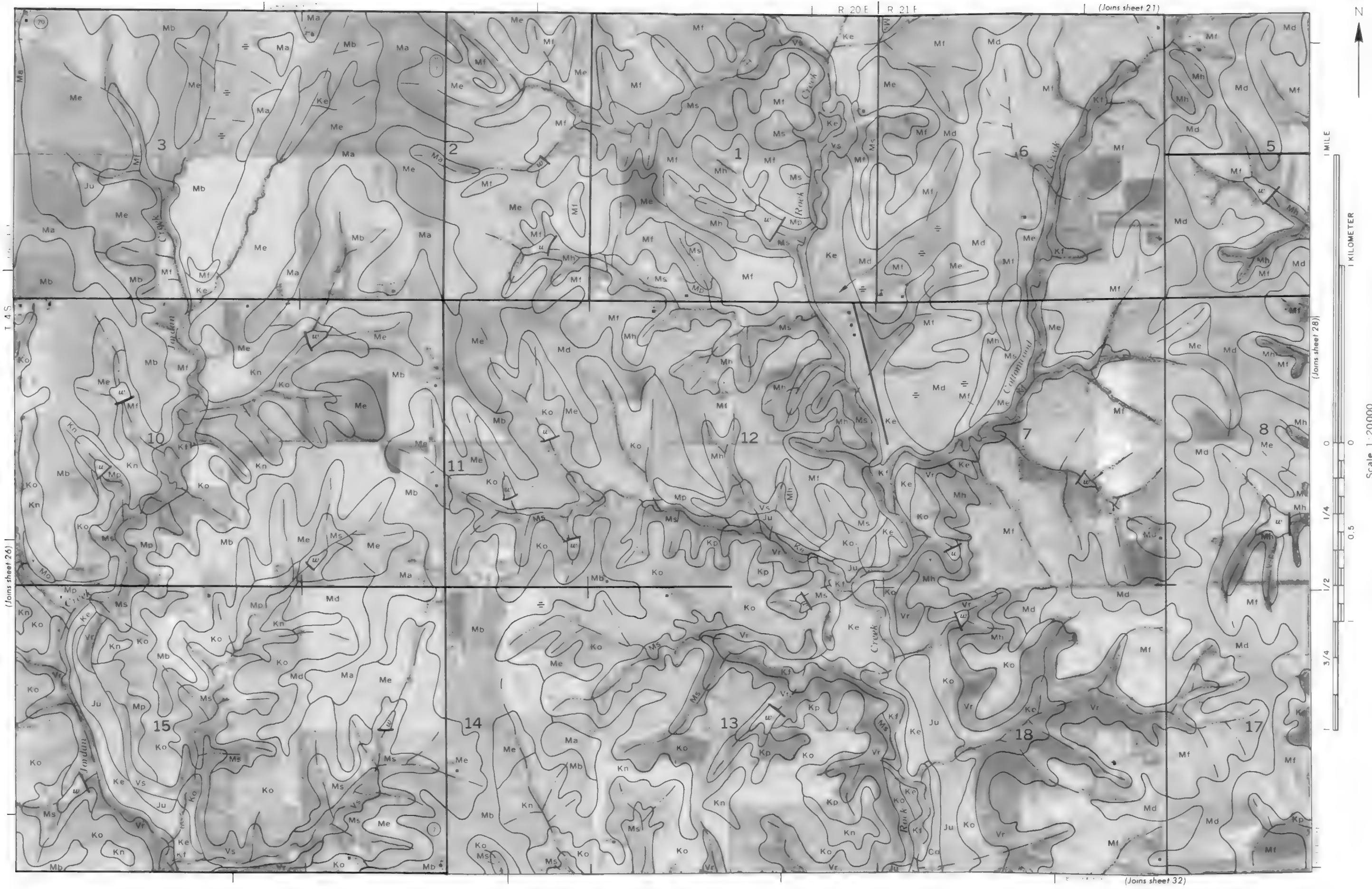
(Joins sheet 23)

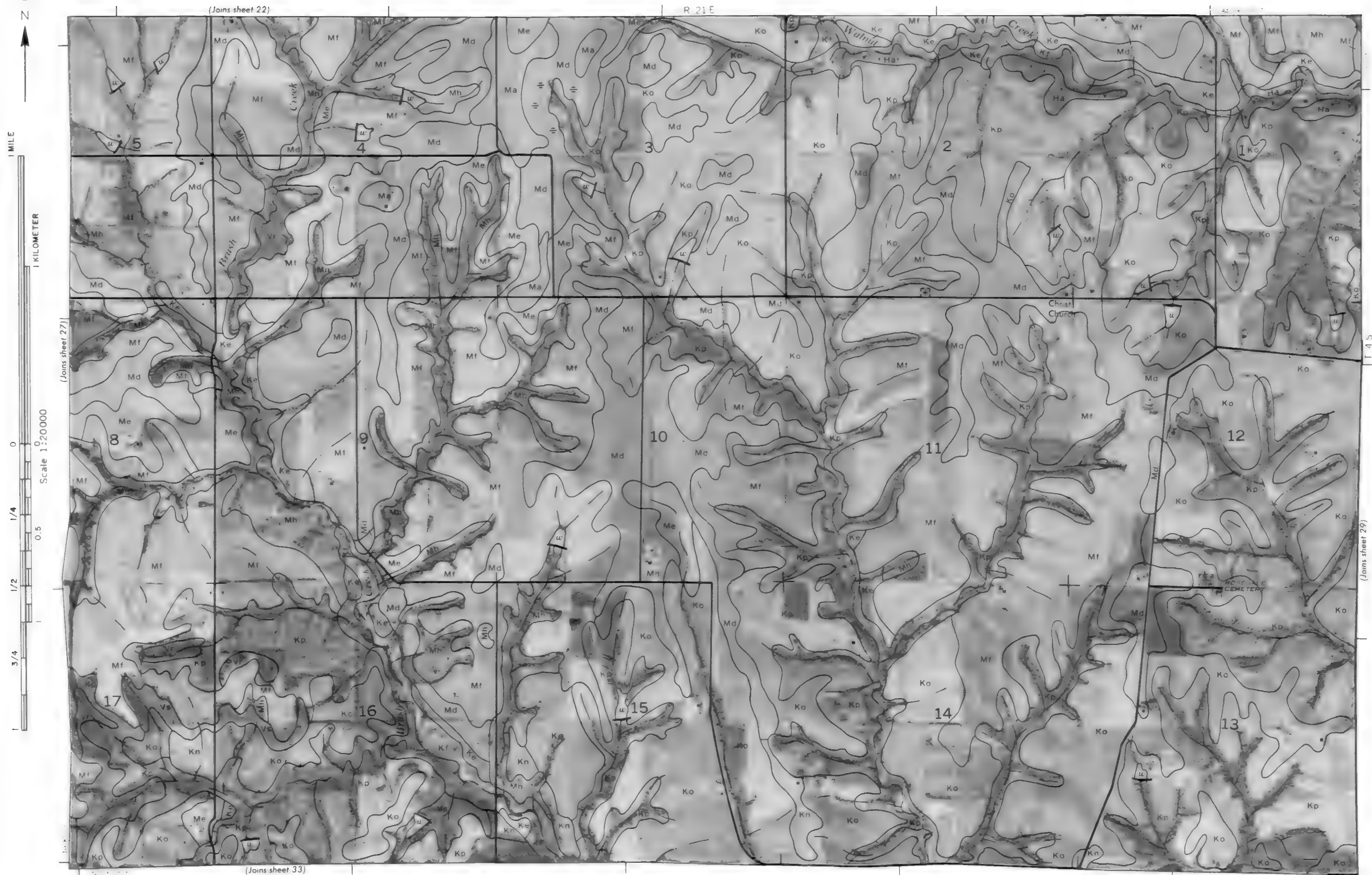


(Joins inset, sheet 6)











KILOMETER

0

(Joins sheet 25)

R. 19 E



1 MILE

1 KILOMETER

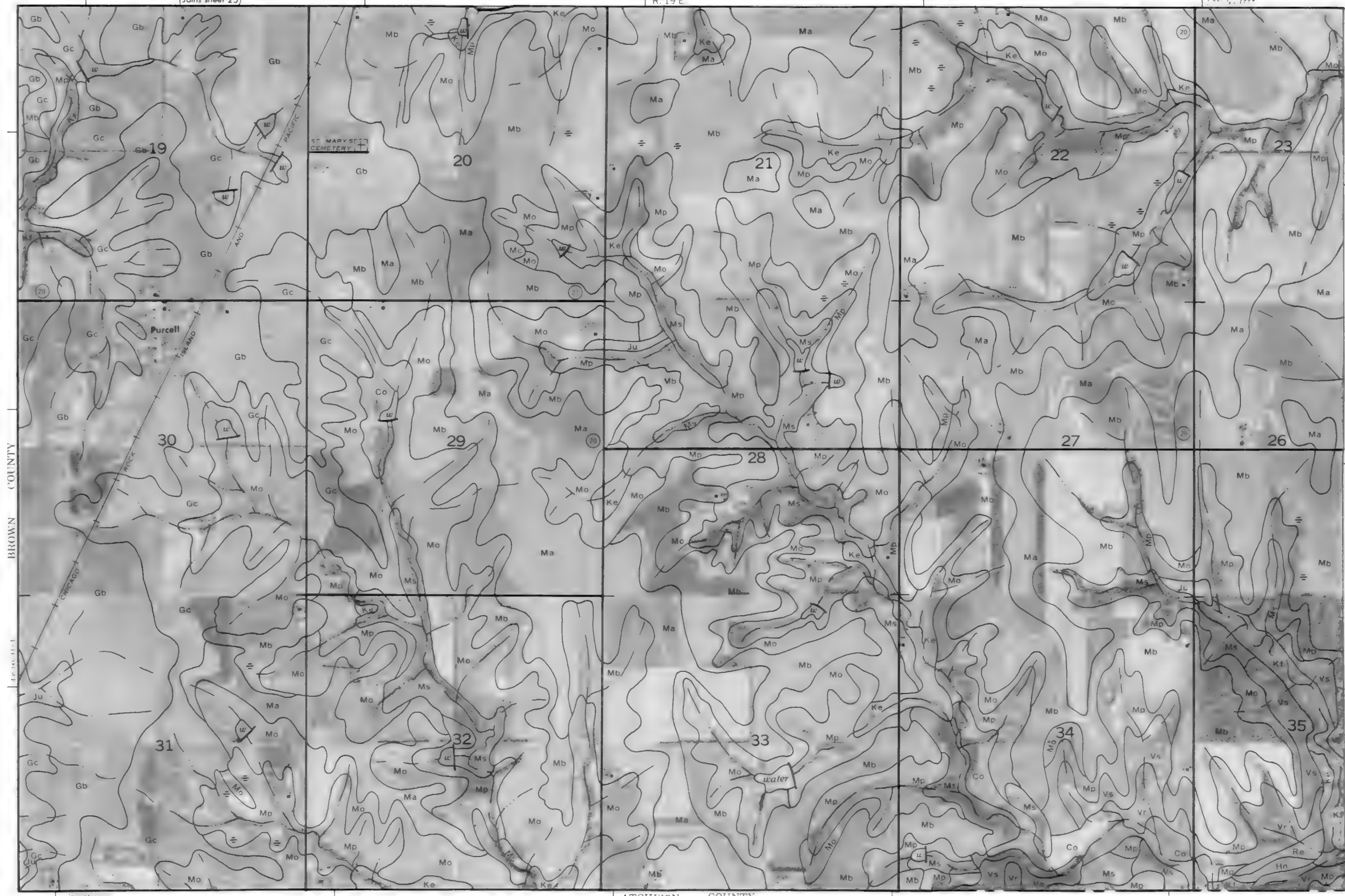
Scale 1:20000

1/4

0.5

1/2

3/4



BROWN COUNTY

ATCHISON COUNTY

T. 4 S

(Joins sheet 31)

R. 19 E. R. 20 E.

(Joins sheet 26)

2 775 000 FEET



1 MILE

1 KILOMETER

(Joins sheet 32)

Scale 1 : 20000

0

0

1/4

1/2

3/4

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

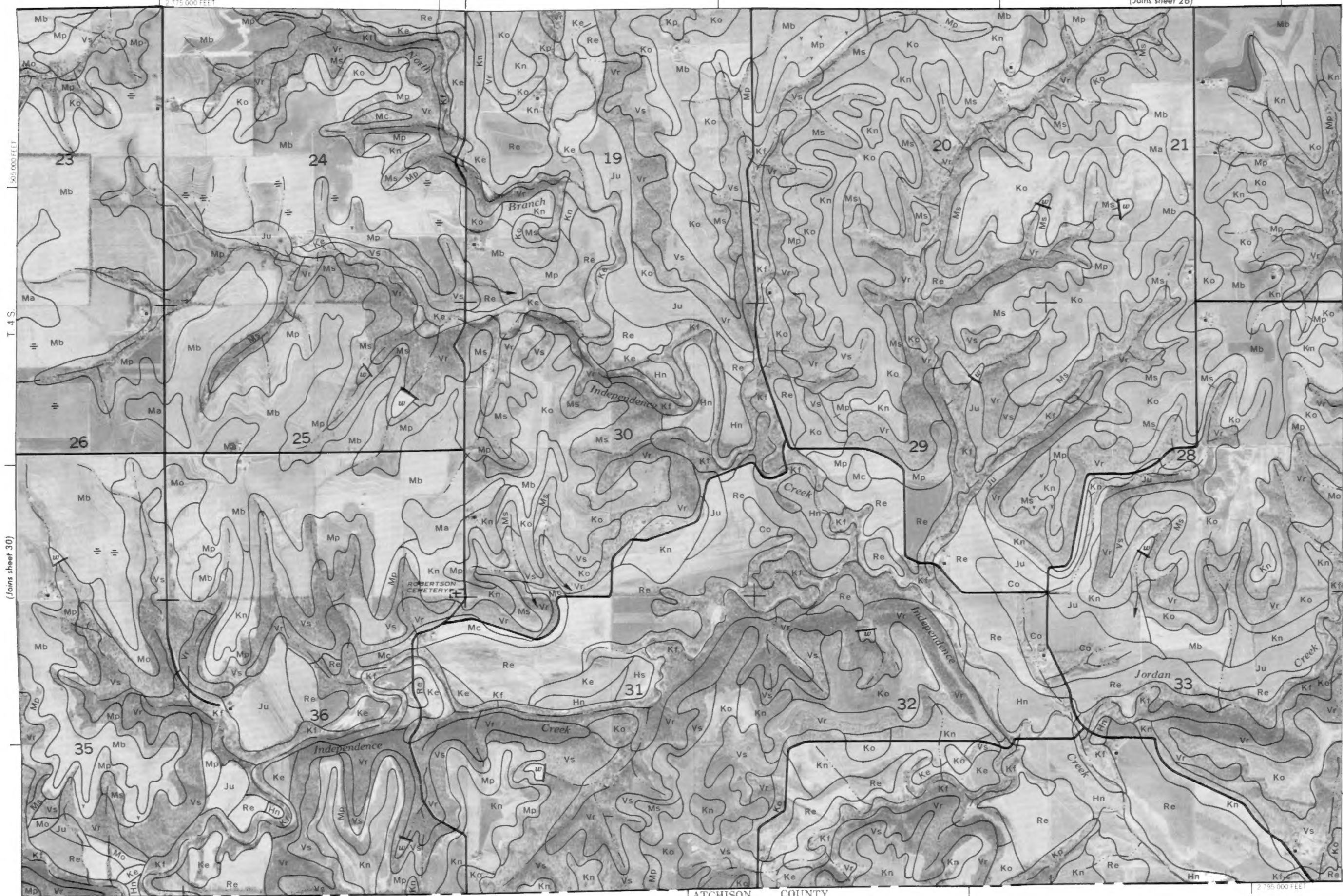
1

1

1

1

1



ATCHISON COUNTY

2 795 000 FEET



(Joins sheet 32) (Joins sheet 33)

R. 21 E.

2 835 000 FEET

